BRL-CR-687

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CONTRACTOR REPORT BRL-CR-687

BRL

PERFORMANCE TESTS OF A FAST-ACTING VALVE FOR THE DRIVER TUBES OF A LARGE BLAST/THERMAL SIMULATOR

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EG&G IDAHO, INC.

MAY 1992

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BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

NOTICES

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
May 1992

3. REPORT TYPE AND DATES COVERED
Final, Jan 91-Jan 92

4. TITLE AND SUBTITLE
Performance Tests of a Fast-acting Valve for the Driver Tubes of a Large Blast/Thermal Simulator

5. FUNDING NUMBERS
C: DE-AC07-76ID01570

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
EG&G Idaho, Inc.
Idaho Falls, ID 83415

8. PERFORMING ORGANIZATION REPORT NUMBER
EGG-ME-10066

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Ballistic Research Laboratory
ATTN: SLCBR-DD-T
Aberdeen Proving Ground, MD 21005-5066

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
BRL-CR-687

11. SUPPLEMENTARY NOTES
Prepared for the U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground , Maryland, under Contract No. DE-AC07-761D01570. Contracting Officer's Representative for this report is Dr. Bruce P. Bums, U.S. Army Ballistic Research Laboratory, ATTN: SLCBR-IB-M, Aberdeen Proving Ground, MD 21005-5066.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This document describes the testing of a fast-acting throat valve element designed by Eaton Consolidated Controls for use in driver tubes, (blast generators) of a Large Blast/Thermal Simulator (LB/TS). An LB/TS is used to simulate decaying blast waves such as are generated by nuclear explosions. The Eaton Throat Valve Element (ETVE) was tested at the Idaho National Engineering Laboratory (INEL) to evaluate its performance against the design criteria. The ETVE was mounted at the end of a driver tube and actuated 16 times at 6 different driver pressures ranging from 396 kPa to 12.4 MPa (57.5 psi to 1,800 psi). The valve seals survived successfully all 16 tests with the driver gas at room temperature and maintained an acceptable leak rate throughout the test program. The average valve lag time was determined to vary from 36 to 120 ms; however, the valve was found to chatter, going through several (up to 20) opening/closing cycles after actuation before settling in the open position. An increase in the pneumatic supply pressure driving the valve showed a minor decrease in the number of chattering cycles. When the valve was actuated with no pressure in the driver tube, no chattering was observed. At the conclusion of the test sequence, the valve seals were inspected and were in good condition. The shock waves appeared to agree with code predictions when the chattering effects were disregarded.

14. SUBJECT TERMS
sleeve valves, gas dynamics, relief valves, reaction time, blast waves, cut off valves, blast simulator, shock tubes, pneumatic valves, high pressure valves

15. NUMBER OF PAGES
57

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

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ACKNOWLEDGMENTS

This testing program was conducted by EG&G Idaho, Inc., 1955 Fremont Avenue, Idaho Falls, ID, 83415 at the Idaho National Engineering Laboratory under DOE contract No. DE-AC07-76ID01570 for the U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD. The U.S. Army Ballistic Research Laboratory technical monitors were Richard J. Pearson and Klaus O. Opalka.

The EG&G Idaho, Inc. Project Manager was Marcela R. Stacey. She was assisted with design and testing by W. David Willis, Paul R. Schwieder, and H. James Hall.

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I. INTRODUCTION

The first phase of the LB/TS work at the Idaho National Engineering Laboratory (INEL) began during early 1988, and continued until November 1990. The results of Phase I were reported November 1990 in the EGG-ME-9358 Large Blast/Thermal Simulator Insulation/Valve Testing Informal Report. The test facility was left in stand-by conditions to await additional funding for continuing the testing of the Eaton Throat Valve Element (ETVE). The funding for Phase II became available during the Spring of 1991 and work was resumed thereafter.

The Phase II for LB/TS test program at the INEL was carried out under DOE contract No. DE-AC07-76ID01570 for the US Army Ballistic Research Laboratory (BRL) at the Aberdeen Proving Ground, Maryland. Calculations documenting the design, fabrication and inspection of the shock tube assembly, and the work and testing performed by the INEL are contained in the EG&G Engineering Department Project File No. 015272. This file will be kept in storage at the EG&G Document Control Unit for twelve months after project completion.

Phase II of this test program had three major objectives.

a. EVALUATE THE SPEED AND ACCURACY OF THE ETVE

The time between the command signal and the first valve motion, termed the opening lag time, was evaluated. The opening lag time of the valve is important because it must be known in order to coordinate the opening of several valves. Multiple valves opening at the same time will be used in large blast simulators. The opening lag time was measured at various driver gas and actuating pressures.

b. MEASURE THE PERFORMANCE OF THE ETVE IN RELATION TO THE FLOW SHOCK FORMATION

The performance of the ETVE in relation to the flow shock formation was measured by recording pressure histories at a number of points in an expansion tunnel mounted downstream of the ETVE.

c. ASSESS THE PERFORMANCE OF THE ETVE SEALS

The performance of the ETVE seals was assessed by measuring the leak rate through the ETVE prior and subsequent to each blowdown. The seals were inspected after all the testing was done, and they were in good condition with no deterioration noted as a result of the cyclic testing. All sixteen tests were performed with the same set of seals and there was no need to replace them.

II. TEST APPARATUS AND INSTRUMENTATION

The LB/TS model shock tube facility is composed of eight main components or systems. A schematic of the overall testing assembly layout is presented in Figure 1.

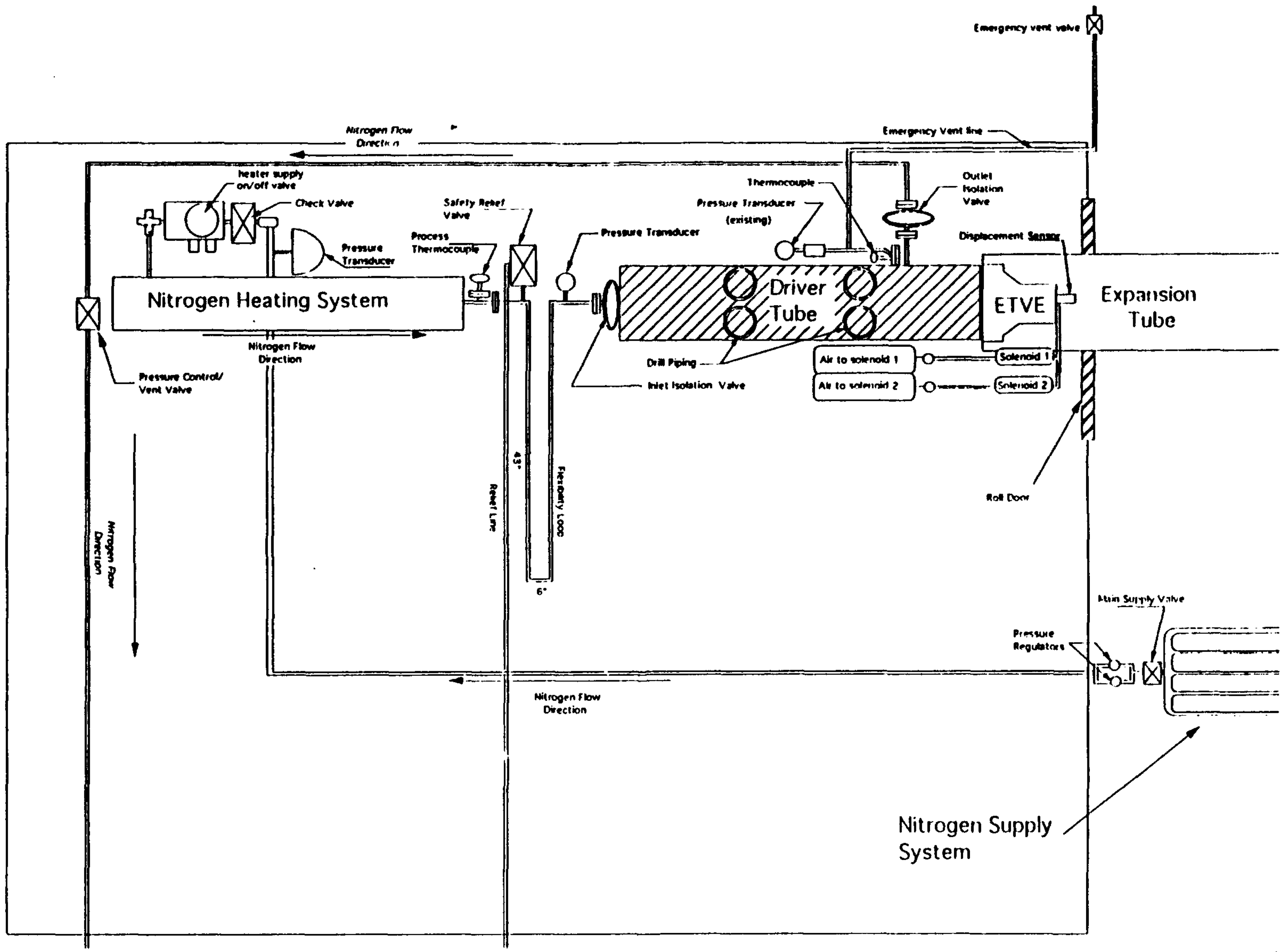

Figure 1. Testing Assembly Layout

Figure 1. Testing Assembly Layout.

1. THE DRIVER TUBE

The driver tube was built by Thermal Sciences Incorporated (TSI) ST. Louis, Missouri. The driver tube is composed of three four-foot long sections. Each driver tube section is made up of a two-foot section of 14 inch schedule 140 pipe welded to two standard 1500 lb-14 inch welding neck flanges (Figures 2 and 3). One end of the driver tube was equipped with a remotely operated inlet valve, and the other end housed the remotely actuated Eaton Throat Valve Element (ETVE) to be tested. Attached beyond the ETVE was the expansion tunnel described in section II.8. below.

2. THE NITROGEN HEATING SYSTEM (NHS)

The NHS is a 30 KW immersion electric type heater. This heater remained in the system as an integral part of the piping. No power was supplied to the heater during Phase II since the testing was done with the driver gas at room temperature. The heating capability was used only during Phase I.

3. THE NITROGEN SUPPLY SYSTEM (NSS)

The NSS was made up of a bank of 6 Kpsi nitrogen cylinders manifolded together. The cylinders were exchanged as needed through the test series to ensure there was an adequate supply of pressure and volume of nitrogen for each test performed.

4. THE SAFETY RELIEF VALVE/VENT AND THE OVERPRESSURE VENT SYSTEM

Both the Safety Relief Valve/Vent and the Overpressure systems were designed to ASME/ANSI B31.1, 1980 ed., Power Piping Code. The safety relief system was comprised of a safety relief valve (SRV) and the piping used to vent the system if the SRV was actuated. The SRV was purchased to comply with the ASME Section VIII Division 1 Boiler and Pressure Vessel Code as it specifically applies to safety relief valves. The valve was located between the NHS and the driver tube to provide safety pressure relief for both the NHS and the driver tube. A complete analysis and design documentation for the safety relief valving and piping is documented in the EG&G Project File No. 015272.

The venting system is the piping necessary to appropriately vent the nitrogen to the atmosphere in the event of overpressure conditions, also labeled "Relief Line" in Figure 1. As with the Safety Relief System, the piping was analyzed for thermal, dynamic, and static loading in accordance with the ASME/ANSI B31.1 Power Piping Code. This analysis is documented in the EG&G Project File No. 015272.

5. THE EATON THROAT VALVE ELEMENT (ETVE)

The ETVE is a fast acting-sliding action valve built by Eaton Consolidated Controls for the flow control of the blast generators of the LB/TS. It is operated by applying 1600-3000 psig of air to two solenoid valves. One solenoid valve opens the ETVE and the other closes

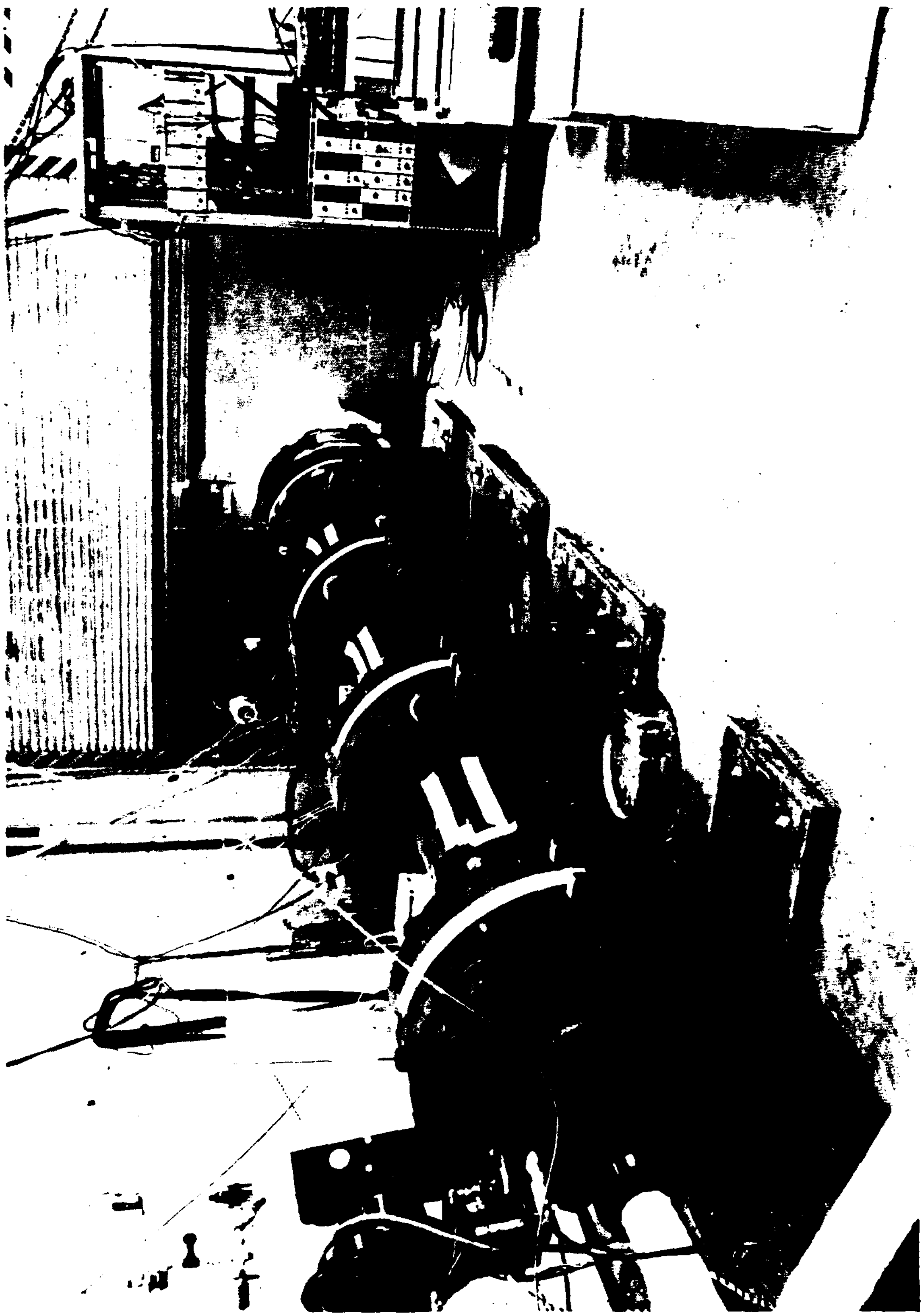

Figure 2. Driver Tube.

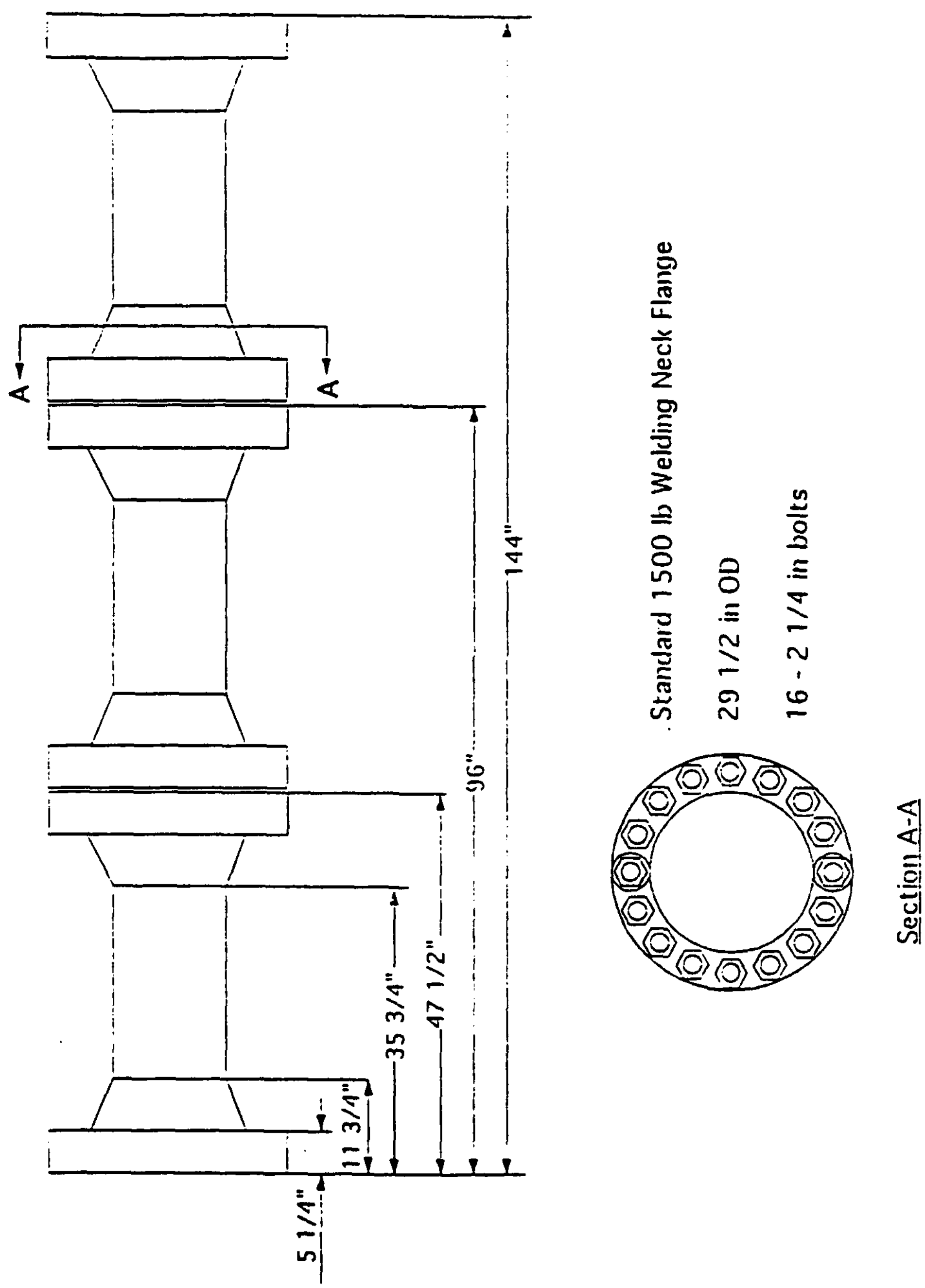

Figure 3. Driver Tube Diagram.

the ETVE. The lag time of the valve varied from 36 to 120 milliseconds from the time the fire signal was initiated to the time the first movement of the Hall Effect Sensor (labeled "Displacement Sensor" in Figure 1) was detected. A schematic of the ETVE is shown in Figure 4. Figure 5 shows a downstream view of the ETVE and Figure 6 shows the Throat Element disassembled.

During Phase II, a seal arrangement (different from that used during Phase I) was proposed by EG&G personnel to the BRL. BRL and Eaton concurred with this proposed arrangement since Eaton could not propose another arrangement that seemed more suitable to them. This arrangement constituted using the same system of O-rings and soft seals in all the grooves (including the grooves which travel over the portholes). This method proved effective, and all tests were performed with the same set of seals. A video tape has been forwarded to the BRL in the format of a step-by-step instruction on how to dis/assemble the ETVE with the current seal arrangement and the overall dis/assembly of the complete ETVE structure.

NOTE: It is of importance to notice that the full scale LB/TS testing will involve heated nitrogen. The seal performance has only been tested under room-temperature driver gas conditions.

6. THE DATA ACQUISITION SYSTEM (DAS)

Two different types of computerized data acquisition were used during Phase II. The instrument/channel relationship for the RC ISC-16/CR card is outlined below.

Channel No.	**Signal Recorded**
1	ETVE Fire
2	ETVE Hall Effect
3	Pressure transducer in expansion tunnel at 10ft
4	Pressure transducer in expansion tunnel at 18ft
5	Pressure transducer in expansion tunnel at 31ft
6	Pressure transducer in expansion tunnel at 40ft
7	Pressure transducer in expansion tunnel at 54ft
8	Pressure transducer in expansion tunnel centerline at 18ft

a. Kaye 7000MDAS: This system interfaced to an IBM AT personal computer. The Kaye is a high speed data acquisition, signal conditioning, and data recording system capable of a continuous sampling rate of up to 20,000 samples per second. Expandable modules allow the Kaye to provide amplification, multiplexing, and analog-to-digital

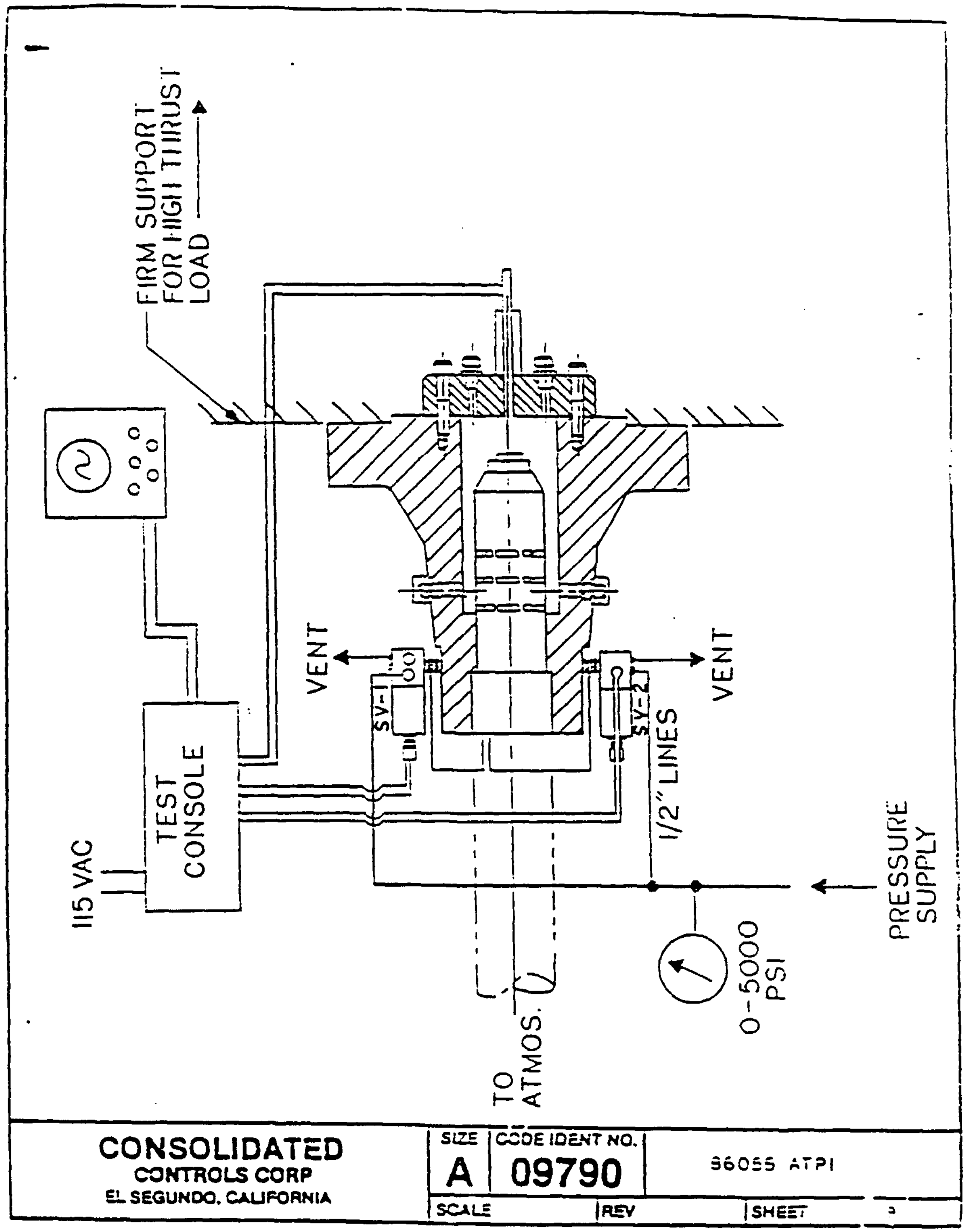

Figure 4. Eaton Throat Valve Element Schematic.

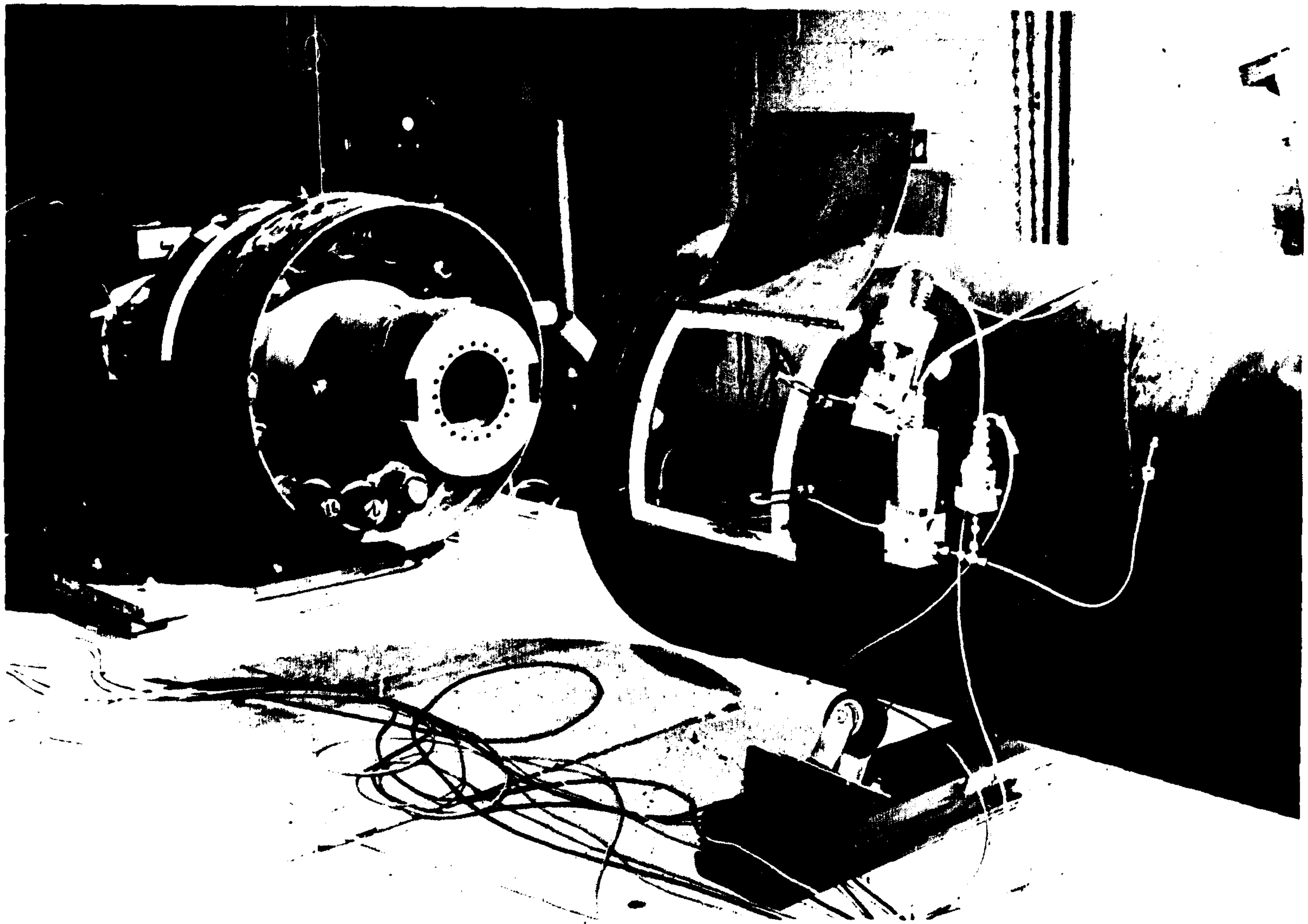

Figure 5. Eaton Throat Valve Element - Downstream View.

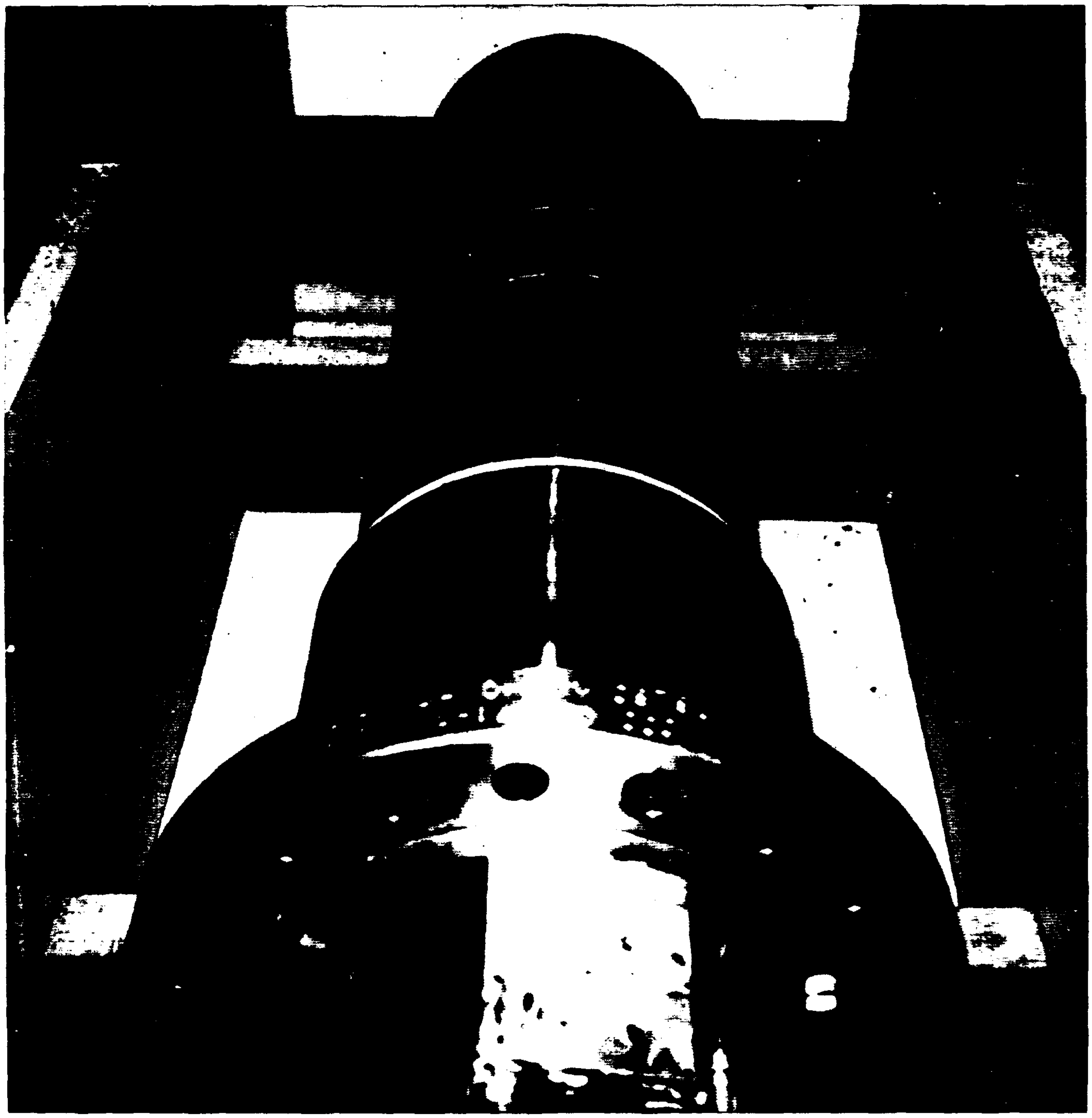

Figure 6. Eaton Throat Valve Element.

conversion for up to 10 channels of differential input. The IBM AT is used to perform engineering unit conversions and obtain calculated parameters from various measurements.

b. RC ISC-16/CR card: This multiplexing card was purchased from RC Electronics of Santa Barbara, California, as a request by the BRL for ease of use and compatibility with the DAS used at BRL. This card was used in connection with a Compaq LTE 386/20. The system was capable of an aggregate throughput of 160,000 samples per second to system Random Access Memory (RAM). This system recorded the signal from the displacement transducer and the expansion tunnel pressure transducers.

7. FACILITY FLOOR MODIFICATIONS

The facility floor was modified to resist up to 53,000 lb-ft expected thrust. Cradles were built for the driver tube which transferred the thrust to drill piping fixed into the lava rock beneath the facility floor. Figure 7 shows the cradles and drill piping above floor level. These are the same structures used during Phase I.

8. EXPANSION TUNNEL

The expansion tunnel is a 100 ft long steel tube with 0.137 inch wall thickness. A shock wave is formed here after the ETVE is actuated and the nitrogen is released from the driver tube. Five pressure transducers were located along the tunnel: at 10 ft, 18 ft 6 in, 31 ft 8 3/4 in, 40 ft 1 1/4 in, 53 ft 5 3/4 in, and a head-on transducer located in the centerline of the tunnel at 18 ft from the ETVE. See Figure 8. All these measurements were referenced from the upstream end of the expansion tunnel.

III. WORK PERFORMED

This Section describes the work performed in order to accomplish the three major objectives as listed in Section I of this report.

1. SCOPE OF WORK

To complete the test project, three major tasks had to be accomplished. These are (a) the test preparation, (b) the test execution, and (c) the facility clean-up.

a. Test preparation. In preparation for the valve testing, the interior insulation of the driver tube was removed, and the inside walls were polished. The driver tube was reassembled and the ETVE was reinstalled. The driver tube was then recertified at 125 percent of the maximum operating pressure of 1800 psig. (Note that the recertification of the driver tube is part of the test preparation, not the execution of the test).

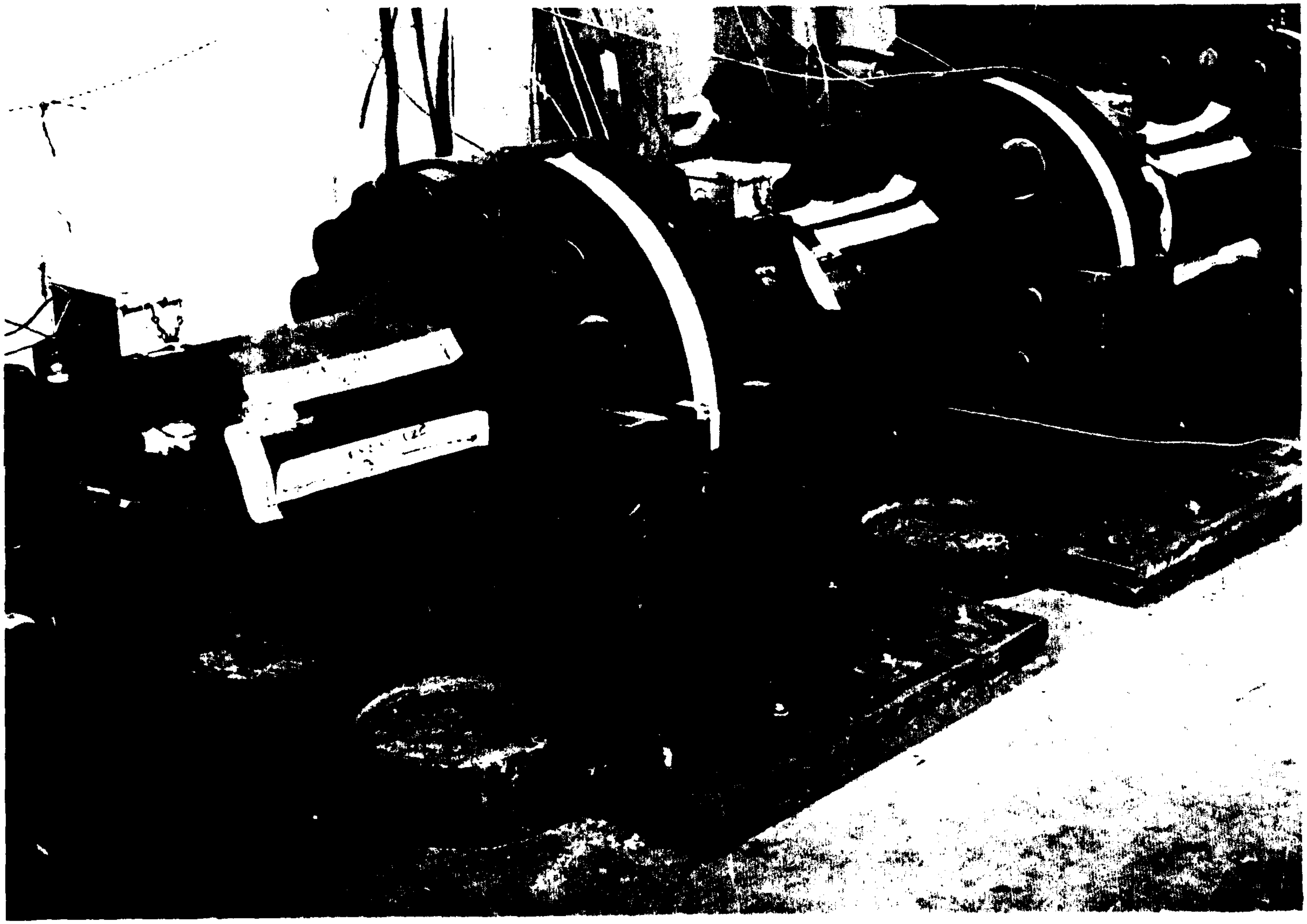

Figure 7. Driver Tube Anchoring System.

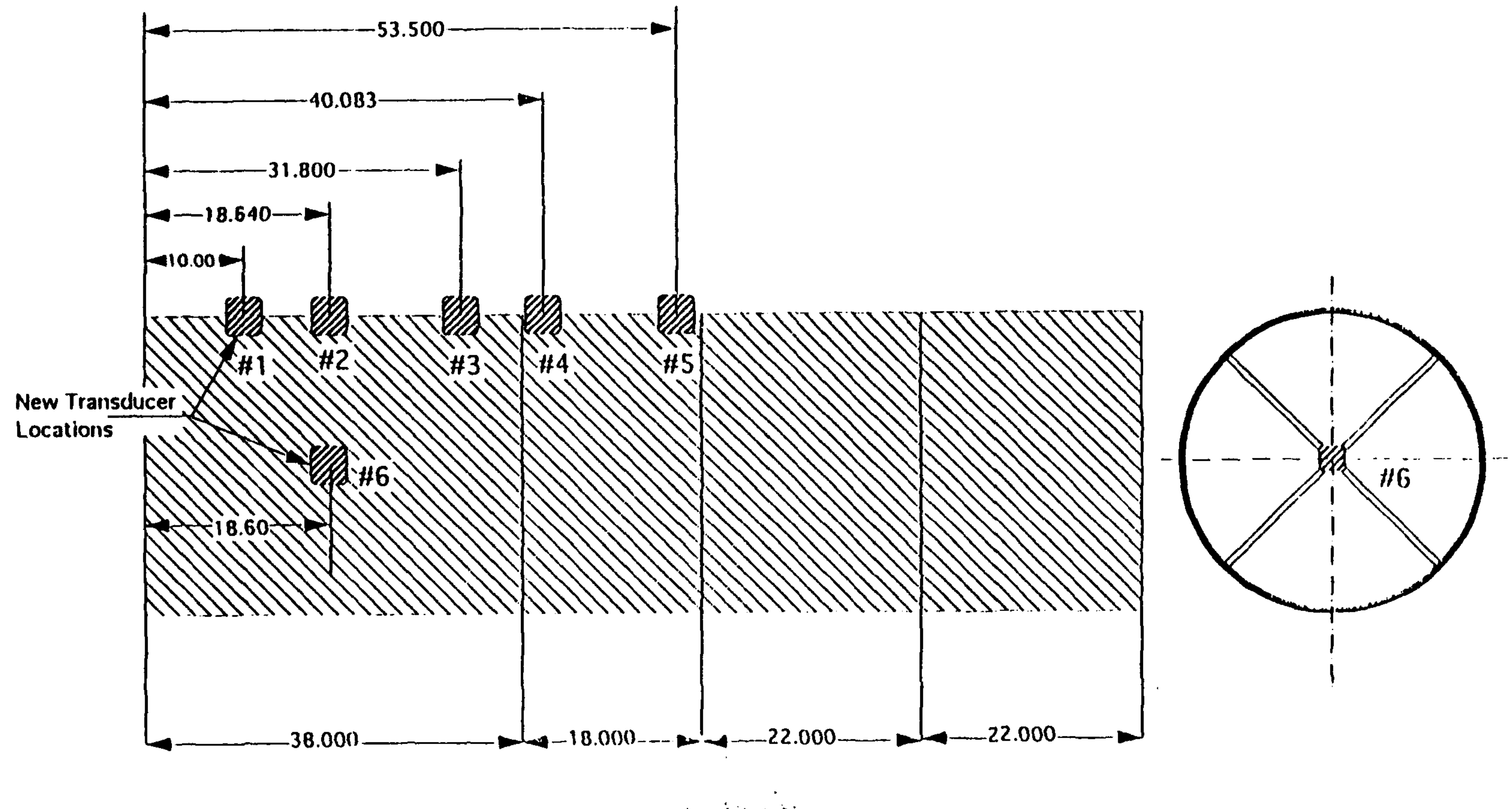

Figure 8. Expansion Tunnel Pressure Transducers Location - Schematic.

b. Test execution. Testing of the ETVE commenced on November 5 and was completed on November 25, 1991. A total of sixteen tests were performed under conditions outlined in Table 1.

c. Facility clean-up. After completion of the tests, the test system was disassembled and the equipment which was purchased with US Army funds was returned to the BRL (Attachment 2 lists the equipment returned to BRL).

2. ETVE TESTS

This section describes the testing performed in the order of increasing driver tube pressures. Test conditions and test notes have been transcribed from the original test log to Table 1 of this report for ease of reference. The actual (chronological) order of the tests is indicated in Table 1, where the date each test was performed is indicated.

The testing was performed in accordance with the EG&G Operating Procedures 246 (OP-246). The data recorded in the test log has been summarized in Table 1. The original copy of OP-246 (test log) will remain in the EG&G Project File No. 015272.

It is of importance to note that the ETVE control box did not provide flexibility in choice of dwell times. The dwell time was fixed by Eaton to be one second from the time the signal is sent to the valve to open, and the time the next signal is sent to close the valve. Therefore, any reference made to the dwell time in the OP-246 has been marked with an N/A.

It should be noted that the LED's which were used during Phase I testing to indicate if the ETVE was ready to fire were disconnected by Eaton during Phase II. Therefore, the OP-246 have N/A's indicated in all the steps making reference to the LED's.

3. DATA ACQUISITION

The data recorded during the testing were recorded in two different data acquisition systems as described in section II.6 of this report. The diagnostics data will be transferred to the US Army BRL as a summary in Table 1 along with other data and observations of interest for each test performed.

In addition to this report, a data file containing printouts from the ISC-16SH card will be forwarded to the US Army. The raw and reduced data acquired from the ETVE hall effect sensor and the pressure transducers in the expansion tunnel will be transferred to the US Army in a 44MB Bernoulli disk.

Back-up copies of these electronic files and of the data printouts will remain stored in EG&G's Document Control storage area for 12 months after the project completion.

Table 1

TESTS PERFORMED (Summary of Conditions)

Test No.	Date 1991	Driver Press. (psi)	Approx. Valve Lag Time (msec)	ETVE Open Press. (psi)	ETVE Close Press. (psi)	ET Temp. (C)	DT Temp. (C)	Barometric Press. In. Hg (psi)	Leak Rate %/min.	Location	Press. Xducers in ET Serial Number (psi)	TEST NOTES
TST 60	11-25	59.70	64	2645	1557	0.18	1.70	25.314 (12.429)	See test	10 ft	708-912 (5)	The driver tube inlet valve leaks into driver tube from
									notes	18 ft	708-913 (5)	supply. Cannot obtain leak rate accross ETVE.
										31 ft	708-914 (5)	
										40 ft	708-915 (5)	
										54 ft	708-917 (5)	
										H-ON	708-916 (5)	
TST2-60	11-25	58.80	60	2610	1557	0.18	2.10	25.314 (12.429)	See test	10 ft	708-912 (5)	The driver tube inlet valve leaks into driver tube from
									notes	18 ft	708-913 (5)	supply. Cannot obtain leak rate accross ETVE.
										31 ft	708-914 (5)	
										40 ft	708-915 (5)	
										54 ft	708-917 (5)	
										H-ON	708-916 (5)	
TST3-60	11-25	58.00	56	2610	1557	0.18	2.50	25.314 (12.429)	See test	10 ft	708-912 (5)	The driver tube inlet valve leaks into driver tube from
									notes	18 ft	708-913 (5)	supply. Cannot obtain leak rate accross ETVE.
										31 ft	708-914 (5)	
										40 ft	708-915 (5)	
										54 ft	708-917 (5)	
										H-ON	708-916 (5)	
TST 235	11-5	240.00	96	1600.00	1500.00	3.50	5.80	25.341 (12.442)		10 ft	708-912 (5)	130 psi left in driver after blowdown completed. Customer
										18 ft	708-913 (5)	agrees no need to perform both pre and post blowdown
										31 ft	708-914 (5)	leak rate checks. Left 50 psi transducer in Head-on
										40 ft	708-915 (5)	with customer concurrence.
										54 ft	708-917 (5)	
										H-ON	708-924 (50)	
TST2-235	11-12	240.00	88	1800.00	1600.00	4.00	6.50	25.341 (12.442)		10 ft	708-912 (5)	During this test, the lead to the Hall Effect sensor broke
										18 ft	708-913 (5)	approx. 20 msec after ETVE was fully open.
										31 ft	708-914 (5)	ETVE close data is not available. Open data is good.
										40 ft	708-915 (5)	Very windy weather conditions. 5psi transdducers noisy due
										54 ft	708-917 (5)	to strong winds.
										H-ON	708-924 (50)	
TST3-235	11-22	245.00	40	2914.00		3.00	6.20	25.612 (12.575)	9.20	10 ft	708-912 (5)	After attempting to characterize the pressure drop in the
										18 ft	708-913 (5)	driver tube in more detail, it was observed that the Press. trans.
										31 ft	708-914 (5)	in the driver tube was not indicating any detailed pressure
										40 ft	708-915 (5)	drop in signal (DAS). The DT pressure transducer
										54 ft	708-917 (5)	was put back in the slow DAS and the ET54ft transducer
										H-ON	708-923 (15)	was reconnected to the high speed DAS for this test.
												(See notes for TST 3-600) Very windy weather.

Table 1

TESTS PERFORMED (Summary of Conditions)

Test No.	Date 1991	Driver Press. (psi)	Approx. Valve Lag Time (msec)	ETVE Open Press. (psi)	ETVE Close Press. (psi)	ET Temp. (C)	DT Temp. (C)	Barometric Press. In. Hg (psi)	Leak Rate %/min.	Location	Press. Xducers in ET Serial Number (psi)	TEST NOTES
TST 600	11-5	600.00	112	1600.00	1500.00	3.50	0.50	23.341 (11.460)		10 ft	708-918 (15)	All ET transducers read well. Spider transducer possibly
										18 ft	708-920 (15)	misaligned. Signal appears confusing.
										31 ft	708-921 (15)	
										40 ft	708-922 (15)	
										54 ft	708-923 (15)	
										H-ON	708-924 (50)	
TST2- 600	11-12	600.00	112	1880.00	1600.00	4.00	8.50	25.341 (12.442)		10 ft	708-918 (15)	No signal on the ET54ft. Transducer got knocked off the
										18 ft	708-920 (15)	ET when it was disassembled to change the Head-on
										31 ft	708-921 (15)	transducer. Testing was done in the dark, and was
										40 ft	708-922 (15)	difficult to see outside.
										54 ft	708-923 (15)	
										H-ON	708-919 (15)	
TST3-600	11-22	602.00	40	2942.00	1500.00	6.00	7.00	25.61 (12.57)	6.92	10 ft	708-918 (15)	In an attempt to characterize the pressure drop in the
										18 ft	708-920 (15)	driver tube in more detail, the ET54ft was omitted
										31 ft	708-921 (15)	and the pressure transducer in the driver tube was
										40 ft	708-922 (15)	connected to the high speed DAS in its stead. This is
										54 ft	See Test Note	why the ET54ft does not provide signal during this test.
										H-ON	708-923 (15)	
TST 900	11-5	900.00	60	1850.00	1730.00	2.60	4.60	25.341 (12.442)		10 ft	708-918 (15)	Spider transducer seems noisy. Transducer was realigned.
										18 ft	708-920 (15)	
										31 ft	708-921 (15)	
										40 ft	708-922 (15)	
										54 ft	708-923 (15)	
										H-ON	708-924 (50)	
TST2-900	11-12	900.00	120	1800.00	1500.00	11.70	6.00	25.341 (12.442)		10 ft	708-918 (15)	The data was immediately looked at after blowdown.
										18 ft	708-920 (15)	Suspected chattering still appeared. The Head-on
										31 ft	708-921 (15)	transducer had become disloged from its position.
										40 ft	708-922 (15)	Therefore, there is no reading on that transducer for
										54 ft	708-923 (15)	this test. Customer requests tests be performed
										H-ON	708-924 (50)	on the low driver pressure ranges only.
TST3-900	11-22	900.00	36	3010.00	2000.00	12.00	3.50	25.61 (12.57)		10 ft	708-918 (15)	In an attempt to characterize the pressure drop in the DT
										18 ft	708-920 (15)	in more detail, the ET54ft was omitted and the press. trans.
										31 ft	708-921 (15)	in the driver tube was connected to the high speed DAS in its
										40 ft	708-922 (15)	stead. This is why the ET54ft does not provide signal during
										54 ft	See test notes	this test. ET18ft fell off or got knocked off. Hall effect dislodged
										H-ON	708-929 (50)	40 msec after open. Good open data.

Table 1

TESTS PERFORMED (Summary of Conditions)

Test No.	Date	Driver	Approx. Valve	ETVE Open	ETVE Close	ET Temp.	DT Temp.	Barometric	Leak Rate	Location	Press. Xducers in ET	TEST NOTES
	1991	Press.	Lag Time	Press.	Press.			Press.			Serial Number	
		(psi)	(msec)	(psi)	(psi)	(C)	(C)	in. Hg (psi)	%/min.		(psi)	
TST4-900	11-22	900.00	40	2872.00	1600.00	8.20	4.50	25.61 (12.57)		10 ft	708-918 (15)	In an attempt to characterize the pressure drop in the
										18 ft	708-920 (15)	driver tube in more detail, the ET54ft was omitted
										31 ft	708-921 (15)	and the pressure transducer in the driver tube was
										40 ft	708-922 (15)	connected to the high speed DAS in its stead. This is
										54 ft	See test notes	why the ET54ft does not provide signal during this test. Hall
										H-ON	708-929 (50)	Effect dislodged 100 msec after open. Good open data.
TST 1200	11-25	1200.00	44	3092.00	1500.00	1.90	16.20	25.314 (12.429)	6.45	10 ft	708-925 (50)	Hall effect disloged 20 msec after open. Good open data.
										18 ft	708-926 (50)	
										31 ft	708-927 (50)	
										40 ft	708-928 (50)	
										54 ft	708-921 (15)	
										H-ON	708-929 (50)	
TST2-1200	11-25	1200.00	120	1100.00	1500.00	0.00	9.13	25.314 (12.429)	3.12	10 ft	708-925 (50)	ET18ft disconnected 150 msec after fully open. Good open and
										18 ft	708-926 (50)	150 msec of data.
										31 ft	708-927 (50)	
										40 ft	708-928 (50)	
										54 ft	708-921 (15)	
										H-ON	708-929 (50)	
TST 1800	11-25	1199.00	56	3030.00	1480.00	0.50	16.60	25.314 (12.429)	7.87	10 ft	708-925 (50)	Chattering still very obvious. Customer advises this to be
										18 ft	708-926 (50)	the last test at 1800 psi.
										31	708-927 (50)	
										40 ft	708-928 (50)	
										54 ft	708-921 (15)	
										H-ON	708-929 (50)	

Leak Rate in %/min=((P[0.0min] - P[xmin]) / xmin / P[0.0min]) * 100

a. Data Collection.

The primary data collection was performed on a Compaq LTE DOS based PC with a RC electronics high speed data card as the front end. This system collected 8 channels of data at an aggregate rate of 160,000 samples per second. Channels 1 and 2 monitored the Eaton Valve fire signal and the hall effect which monitored the opening and closing of the ETVE. The hall effect signal was amplified with a gain of 1000 while channels 3 thru 8 were amplified with a gain of 50. Channels 3 thru 8 were connected to the pressure transducers on the expansion tunnel. These pressure transducers were excited by a calibrated 10 volts.

Software used to collect data from these channels was furnished by RC electronics. This software was their Electronic Chart Recording package running under their main EGAA software. Due to the aggregate data rate, all data collecting was to a RAM disk located on the PC. The software uses 7 files to contain test configuration and raw data. Each test recorded was saved to a hard disk.

Once the data was collected to the RAM disk, it was written to a hard disk in the raw format in ASCII format for further processing. A file naming convention was adopted to store all the data. All test data start with the characters "tst" followed by the test number and pressure step. For example, there were 4 tests performed with 900 psi pressure in the driver. These tests are labeled sequentially as; tst1900, tst2900, tst3900, and tst4900. This naming convention is applied to all files used by the RC software. The disk directories are also divided using this convention.

b. Data reduction

Once the raw data was collected, an ASCII data set was made for the blowdown region. ASCII data was then imported to a graphics and analyzing package called Dadisp. This package was used to take the gains of the pressure measurements and apply the calibration coefficients generated from the calibration data sheets for each pressure transducer. Data was further expanded to 6000 points around the blowdown and written to disk in an ASCII format. Plots of this data, the complete data set, and an expansion of 1000 points at blowdown has been already forwarded to the US Army in a compiled file (See Attachment 1 for list of equipment and information transferred to the BRL). The ASCII data on disk is found in each of the test directories under extension ".asc" in the Bernoulli disks forwarded to the US Army. The naming convention for this data is:

FIRE.ASC	Fire signal generated at the Eaton Valve control.
HALL.ASC	Hall effect signal on Eaton Valve.
ET10.ASC	Pressure transducer on the expansion tunnel at the 10 feet mark.

ET18.ASC	Pressure transducer on the expansion tunnel at the 18 feet mark.
ET31.ASC	Pressure transducer on the expansion tunnel at the 31 feet mark.
ET40.ASC	Pressure transducer on the expansion tunnel at the 40 feet mark.
ET53.ASC	Pressure transducer on the expansion tunnel at the 53 feet mark.
ETSPIDER.ASC	Pressure transducer located inside the expansion tunnel on a center line at the 18 feet mark.

IV. DISCUSSION OF RESULTS

The results and observations of Phase II will be discussed in the same order the testing objectives were identified in section I of this report. The data analysis will be performed by the Ballistic Research Laboratory (BRL); this section only describes the ETVE's performance as observed during testing. All the raw and processed data has been forwarded to BRL along with printouts of the processed data in plot format for the data acquired by the ISC-16SH card as described in section III.3.b of this report.

1. THE SPEED AND ACCURACY OF THE ETVE

During Phase II, the ETVE was actuated sixteen times at various driver tube pressures varying from 57.7 to 1800 psi. The valve opening lag time, the time the fire signal was initiated until the first detection of movement by the Hall Effect Sensor (HES) was observed. The valve opening lag time varied from 36 to 120 milliseconds. The valve opening lag time appears to be dependant on the actuating pressure rather than on the driver tube pressure. Table 1 of this report indicates the approximate valve opening lag time measured for each test. The Hall Effect Sensor leads fell off the valve in four of the tests. A better attaching mechanism must be developed to secure the Hall Effect in place and/or to strengthen the leads. The dwell time was fixed to 1 second (The specification requested that the valve provide a dwell time variable from 0 to 100 ms).

2. THE PERFORMANCE OF THE ETVE IN RELATION TO THE FLOW SHOCK FORMATION

When there was pressure in the driver tube, the ETVE chattered several times (up to 21 open/close cycles). When there was no driver tube pressure, the ETVE cycled only once to open. The closing cycle was detected only once in all instances.

Several actuating pressures were used for the ETVE open cycle to attempt to eliminate or characterize the ETVE chattering in relationship to the actuating pressure. The number of apparent chattering cycles decreased as either the driver tube pressure was decreased, or as the ETVE actuating pressure was significantly increased. Actuating pressures of 3000 psi produced less "chatter" during the opening cycle than lower pressures used ranging from 1500 psi. The ETVE is currently designed to handle a maximum of 3000 psi of actuating pressure.

3. THE PERFORMANCE OF THE ETVE SEALS

The seal arrangement proposed by INEL was successful at maintaining a maximum leak rate of 7.62% per minute at 1800 psi and decreasing percentage with decreasing driver pressure. The only exception observed was test 3-235 psi which indicated a leak rate of 9.2% per minute. The seal arrangement was only tested successfully for room temperature nitrogen in the driver tube. Caution should be exercised when testing with hot nitrogen, the seal performance may be different under these conditions. There were no tests performed with hot nitrogen with the seal arrangement proposed by INEL.

The specification requested that the valve maintained a leak rate no greater than 15 lbm/hr at 180 psig at room temperature and no greater than 125 lbm/hr at 2250 psig at 700°F. For the conditions the valve was tested during Phase II, the leak rate was estimated at 5.1 lbm/hr at 230 psig.

However, it is of importance to notice that the driver tube isolation valves would leak when subjected to 50 or more pounds of pressure differential across them. This situation indicates that the leak rate calculated is not only the leak across the ETVE alone, but in reality, it is the net pressure differential in the driver pressure caused by leaky inlet and outlet isolation valves, in addition to the leak across the ETVE. The precise leak rate through each isolation valve could not be determined under the current contract due to budgetary constraints.

V. CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

The test series demonstrated that the ETVE conformed to a number of the specifications set for it. However, four critical specifications were not met; leak rate, opening time, dwell time and closing time. The leak rates were not confirmed because the specifications call for operation with hot nitrogen which the existing system could not provide. The leak rate with room temperature gas appears acceptable. The opening time specification was not confirmed because there was no direct method of measuring it and because the pressure records indicate the valve chattered and hence failed to stay open on the first attempt. The valve control system did not provide a variable dwell time as called for in the specification. The closing time was not confirmed because it was not tested in this program in order to concentrate on the problems of valve opening.

In general, the conclusions observed were as follows:

a. The ETVE open lag time varied from 36 to 120 milliseconds. The open lag time appears to be inversely proportional to the actuating pressure used in the ETVE, and not related to the driver pressure.

b. The valve chattered opening and closing several times before settling in the open position. The pressure level achieved when the valve settled in the open position was in agreement with that predicted for a smooth valve opening.

c. The ETVE Hall effect sensor can only indicate that the valve throat moved. No information to determine the direction of the movement or the precise amount of the displacement can be determined from the current configuration as provided by Eaton.

d. The valve seals worked well when the driver tube was pressurized with room temperature gas.

e. Eaton could not repair the control systems for the ETVE to provide a variable dwell time. During Phase II, the dwell time was fixed to one second.

f. The exact leak rate through the ETVE could not be determined because of the unrelated isolation valves leak.

2. RECOMMENDATIONS

It is recommended that the following changes and further tests be performed to more fully characterize the ETVE performance and adherence to the original requirements.

a. Install an LVDT in place of the hall effect sensor. This change would provide information regarding the exact position of the valve throat with respect to time, and not only an indication that the throat moved. A more reliable mechanism needs to be developed to secure the sensor leads in place.

b. Testing should be performed with heated nitrogen in the driver tube. This testing would help determine the seals performance under heat transfer conditions.

c. The ETVE control mechanism needs to be modified to allow for flexibility of the dwell time. If flexible dwell time is unattainable, the Full Scale LB/TS Facility design will have to accommodate the fixed dwell time and program the timing necessary to provide the valves opening sequence as needed. Off-the-shelf systems can be purchased to achieve the same effect.

d. The ETVE would have to be structurally strengthened to allow for greater than 3000 psi actuating pressures. Reducing the "chatter" would possibly provide a clean shock wave in the tunnel.

3. OVERALL VALVE PERFORMANCE

The ETVE showed promise during the phase II testing but failed to meet specifications in a number of areas. The most important problem was valve chatter during opening. If the chattering problem can be overcome, then the design has the potential of being very useful in controlling the flow in large scale blast simulators.

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APPENDIX No.1

LIST OF EQUIPMENT AND INFORMATION FORWARDED TO THE BRL

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LIST OF EQUIPMENT AND INFORMATION

FORWARDED TO THE BRL

1. A video tape containing :

   a) video-audio information on one blowdown at each driver pressure

   b) video-audio information on the dis/assembly of the ETVE and specific seal information

2. Hard copies of all the data printouts from the ISC-16SH acquired data

3. The front end box and the ISC-16SH card from RC electronics SN 0690707 and corresponding manuals

4. One 44MB Bernoulli disk with all the raw and reduced data acquired with the ISC-16SH card

5. Nineteen pressure transducers SN 708-9:12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 29, 30, and 31

6. One expansion module for the LTE Compaq and a 4MB memory expansion module SN 1116HAW10494 Gov. Prop. ID. 296346

7. The driver tube, heater, expansion tunnel and clamping devices, expansion tunnel supports, ETVE and controls, extra bolts, ETVE control boxes, ETVE solenoids, one flowmeter, the flexibility loop and Safety Relief Valve, and instrumentation as it came with the original equipment

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APPENDIX No.2

EATON THROAT VALVE ELEMENT

ENGINEERING SPECIFICATION

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EG&G Idaho, Inc.

FORM EG&G-680
(Rev. 1-87)

ES — 51190 Rev. A
DATE — 3-3-89

SPECIFICATION

LARGE BLAST THERMAL SIMULATOR

FAST ACTING DRIVER TUBE VALVE

Approved for Release:

Margaret L. Nelson
Engineering Graphics
EG&G Idaho, Inc.

EG&G Idaho, Inc.

FORM EG&G-1624
Rev. 03/80

DOCUMENT APPROVAL SIGNATURE SHEET

Type of Document	Document No.
Specification	ES-51190 Rev. A

Title: LARGE BLAST THERMAL SIMULATOR
FAST ACTING DRIVER TUBE VALVE

Prepared By T. R. Reed — Ext. 8425

Originated By T. R. Reed — Ext. 8425

(PRINT OR TYPE NAME IN SPACE ABOVE SIGNATURE)

Approval and Review Signatures	Organization	Mail Address	Date
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	30		

1.0 SCOPE

1.1 Introduction In order to meet the growing need for verification of nuclear blast survivability of military hardware, the US Army is sponsoring research into the design and operation of a Large Blast Thermal Simulator (LBTS) scheduled for completion in the early 1990's. The thermal simulation will be effected by a thermal radiation source based on the combustion of aluminum and oxygen. The blast simulation will be produced by a number of high pressure driver tubes releasing compressed nitrogen gas into a large expansion tunnel. The shock wave will be driven by an array of nine 6-ft diameter steel driver tubes. The shock will be initiated either by rapidly opening a throat valve or by explosively actuating rupture disks downstream of the open throat valves. After the shock is initiated, the throat valves are then closed in a controlled manner to meter the flow, sending forward rarefaction waves which cause the pressure behind the shock to decay in the same manner as a free field blast wave. Prior to the construction of the full scale facility, a prototype LBTS facility will be built to test the driver tube valves and other major components. An existing 8-ft diameter shock tube at the Ballistic Research Laboratory will be modified to house a 3-ft diameter driver tube for a 1/6 scale test facility. This single 36 inch driver tube will be used to represent the nine driver tubes of the full scale facility. Only one valve will be required for the 1/6 scale facility. This valve can be considered a 1/2 scale (on the diameter) prototype of the full scale valves.

1.2 Scope The development of the LBTS valves and associated hardware will be completed in phases, as funding permits. These program phases are listed below. Rev. A

Phase I Conceptual designs evaluated, and a preferred design concept chosen

Phase IIA Design of the complete half scale valve system

Phase IIB A single prototypical element based on the half scale design will be fabricated and tested

Phase IIIA Fabrication of the half scale rupture disk assembly (See Definition Section 1.4)

Phase IIIB Fabrication of the half scale valve assembly which will interface with the equipment constructed in Phase IIIA

Phase IV Design of full scale complete valve system using updated information gathered in testing of the half scale equipment

Rev. A

Phase V Fabrication of full scale complete valve systems

This specification defines the requirements to be used for all the above phases except for Phase I, which is complete.

1.3 Applicability This specification applies to the half scale single complete valve system used to control the gas flow from the driver tubes in the 1/6 scale facility and the nine complete valve systems required for the full scale LBTS facility. The purpose of these valves is to initiate flow from the driver tubes in such a manner that a sharply defined shock is propagated into the expansion tunnel (also referred to as the expansion tube). The valves are then closed in such a manner that the proper pressure profile is developed behind the shock. This specification applies to all items listed in section 1.4.1, complete valve system.

1.4 Definitions

During Phase I and Phase II of the LBTS valve program, delineation of specific valve equipment has become necessary. Identification and description of these components are found below and are the basis for all descriptions and requirements in this specification.

1.4.1 Complete Valve System This includes both the valve assembly of 1.4.2, and the rupture disk assembly of 1.4.5. In general, this includes all portions of the LBTS valve between the driver tube and the expansion tunnel (or expansion tube) as well as all controllers and software. See Figure 1.

1.4.2 Valve Assembly This is the multi-element valve connected directly to the high pressure driver tube. This is also referred to as simply 'valve'. This would include all valve control systems, software, man/machine interface, mounting hardware and support documentation. This is a stand alone assembly which may or may not be operated in conjunction with the rupture disk assembly. It is understood that operation of this valve without the use of the rupture disk assembly, will require the use of the valve assembly expansion tube adapter of section 1.4.3. The valve assembly expansion tube adapter is an optional item, and is not a part of the valve assembly. See Figure 2. Rev. A

1.4.3 Valve Assembly Expansion Tube Adapter This item is to be used only when the valve is being used without the rupture disk assembly. It forms a seal between the outlet of the valve and the expansion tube. This is an optional item and may or may not be procured or used. This item is only applicable to the half scale valve. See Figure 2.

1.4.4 Valve Element This is defined as one of the multiple on/off valve elements used in the valve assembly. See Figure 2.

1.4.5 Rupture Disk Assembly This includes the rupture disk transition piece (1.4.6), rupture disk holder (1.4.7), dual rupture disks, rupture disk assembly seal plate (1.4.8, half scale only), attachment rings, brackets, gaskets, and all mounting hardware. This item is a stand alone assembly, capable of being operated with or without the valve assembly. See Figure 1.

1.4.6 Rupture Disk Transition Piece This item is designed to bolt up to the driver tube directly or to the valve assembly. This item provides for the adaptation of the 36 inch ID of the driver tube or valve to the 18 inch ID of the rupture disk outlet. The rupture disk holder of 1.4.7 mounts to the downstream side of this item. This may be used with or without the valve in place. See Figure 3. **Rev. A**

1.4.7 Rupture Disk Holder This item connects directly to the down stream section of the rupture disk transition piece and is used to hold and seal the rupture disks prior to rupture disk blast initiation. See Figure 3.

1.4.8 Rupture Disk Assembly Seal Plate This item effects the seal between the rupture disk assembly and the 1/6 scale expansion tube. This is a required item for all blast operation, and will be used with or without the valve in place. This item is applicable to the half scale valve only. See Figure 3.

2.0 APPLICABLE DOCUMENTS

2.1 The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issue in effect on the date of invitation to bid shall apply. In the event of a conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

American Society of Mechanical Engineers (ASME)

ASME Boiler and Pressure Vessel Code, Section VIII

American National Standards Institute

ANSI B16.34, Steel Valves, Class 1500

National Electrical Manufacturers Association Standard

3.0 REQUIREMENTS

3.1 General Both the half scale and the full scale valves assemblies shall be delivered as complete units with all supporting hardware, including control system, man/machine interface, and operation/maintenance manuals. Electrical power, low flow rate nitrogen gas at 2100 psig, and utility water will be supplied. The valve assembly shall be delivered as a stand alone system and must be designed for use with or without the rupture disk assembly of section 3.14. It is expected that the rupture disk assembly will be procured first, with the valve procurement following at a later date as funding becomes available. It is required that the valve assembly and the rupture disk assembly be compatible, so that integration of these separately procured items can occur at the facility with no equipment modification. Rev. A

3.2 Design The chosen design concept is a valve assembly containing multiple on/off elements which are individually closed to approximate the required closing curve. All valve assemblies shall contain a minimum of 18 elements. During the opening cycle, the valve elements shall be opened simultaneously, thus minimizing the opening time. During the closing cycle the valve elements shall be closed in such a manner that symmetrical loading is placed on the valve. During some operating conditions, a number of elements will remain in the closed position during the entire valve open/close sequence. When the rupture disks are used to initiate the blast, some or all of the valve elements will begin the blast sequence in the open position, and then close to shape the blast wave. The valve assembly and the rupture disk assembly shall be designed, manufactured, tested and marked in accordance with the requirements of the ANSI B16.34, and the intent of ASME Section VIII (Code stamp is not required). **Rev. A**

3.3 Valve Operating Conditions

Inlet Pressure	35 psig minimum - 2250 psig maximum	
Outlet Pressure without rupture assembly	0 psig	
Outlet Pressure witn rupture disk assembly	0 - 1860 psig for the half scale valve and 0 - 2250 psig for the full scale valve. During a blast sequence, when the rupture disk assembly is used, the full range of pressures may be seen in a single blast sequence	**Rev. A**
Inlet Temperature	-40 F to 700 F	
Outlet Temperature	-40 F to 130 F	

Flow Media Nitrogen Gas

Ambient Humidity 10 - 100%

3.4 Valve Size

3.4.1 Flow Sizing The full scale valve shall provide the same flow rate at all supply pressures as a piece of straight 36 inch ID pipe of the same overall length. The half scale valve shall provide the same flow rate at all supply pressures as a piece of straight 18 inch ID pipe of the same overall length.

3.4.2 End Connection Size Full scale valves shall mate to the 72-in. ID steel driver tubes. The method of connection (welded, flanged, or other coupling such as a Grayloc clamp) shall be determined by the vendor. The downstream portion of the full scale valve assembly (which may or may not include a rupture disk assembly) shall discharge directly into the expansion tunnel with no connection necessary. The upstream side of the 1/2 scale valves shall mate to the 36 inch diameter driver tube flange shown in Figure 4. The downstream side of the 1/2 scale valve assembly shall be mated to the rupture disk assembly or the valve assembly expansion tube adapter. Rev. A

3.4.3 Envelope Size The full scale valve body and actuators shall be capable of fitting within a cylinder 102 inches in diameter, coaxial with the driver tube. The overall length of the full scale valve shall be determined by the vendor. The half scale valve body, actuators and rupture disk assembly shall be capable of fitting within a cylinder 86 inches in diameter, with an overall length of 62.25 to 120 inches (See Figure 5). Although not desirable, some flexibility exists to increase diameter of the upstream 62.25 inches of this valve envelope. EG&G concurrence is required if this increase is necessary. Rev. A

3.5 Valve Element Actuator The primary valve element actuator shall be operated by compressed air or nitrogen. Operator pressures of less than 2100 psig are preferable but not required. If higher operator pressures than 2100 psig are required, the high pressure actuator gas supply shall be furnished by the manufacturer. Although 2100 psig gas pressure will be supplied by the test facility, this will be delivered at a low flow, therefore if high flow is necessary, the vendor will be required to provide the necessary accumulators or other hardware necessary to provide the required nitrogen flow rate. Snubbing of the valve elements shall be of a passive type to prevent unintentional valve damage.

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3.6 Valve Construction

3.6.1 Body Material Material shall satisfy the applicable requirements of ANSI B16.34 and the ASME Code.

3.6.2 Trim Material To be determined by vendor.

3.6.3 Body Type To be determined by the vendor.

3.7 Valve Assembly Expansion Tube Adapter This item shall connect directly to the valve assembly and provide a seal between the valve and the expansion tube. This adapter shall be sized to withstand internal expansion tube pressures of 0 to 50 psia at -40 to 200 F temperature. A lifting eye or eyes shall be provided for installation and removal of the valve assembly seal plate. The adapter shall have an ID of 96 inches to match the existing expansion tube and shall be configured similar to Figure 2. Bottom support saddles shall be as shown in Figure 6. This item applies to the half scale valve only.

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3.8 Valve Performance Characteristics

3.8.1 Opening Performance The valve shall be capable of moving all elements simultaneously from the fully closed to the fully open position in less than 10 ms. The shape of this opening curve is not important.

3.8.2 Closing Performance In the closing direction, not only does the valve have to be fast acting but also precisely timed such that the valve open area verses time plot closely approximates the desired closing schedules as shown in Figures 7A through 7D. These approximate plots apply to the full scale valves only, and are derived from the tabular data listed on each figure. Other closing schedules similar to these shown are expected, and thus the valve should be sufficiently flexible to allow for the programming of varied closing schedules. In the case of the half scale valve, it is desired to close the valve in one sixth the times listed in Figures 7A - 7D. If this becomes economically infeasible, exception can be taken to this requirement and a best effort closing schedule submitted. Additionally, it is desired to open the the valves in one sixth of 10 ms, or 1.7 ms. It is recognized that this will be difficult to achieve, and is not a requirement. However, effort should be made to open the half scale elements as fast as practical to minimize the the usage of the explosive actuated rupture disks.

3.8.3 Dwell Time Dwell time refers to the time the valve is in the fully open position in the open/close cycle. This time should be variable between 0 and 100 milliseconds.

3.8.4 Flexibility All the valve elements shall have the capability to be individually opened and closed or remain in position independent of adjacent valve elements. This valve open/close sequencing programming shall be initiated and controlled from a remote location by electronic means.

3.9 Maintainability The valve elements shall be accessible from the outside of the valve or from the downstream end of the valve assembly. The valve shall be designed to allow reasonably convenient removal or repair of parts subject to wear. Seals shall be replaceable, and seats shall be capable of being re-lapped or replaced. A recommended spare parts list shall be provided with the valve assembly. Special tools which are necessary to maintain the valves shall be provided by the manufacturer.

3.10 Reliability The manufacturer shall provide test data to quantify the reliability of the valve and the expected deviation from the required opening, dwell and closing requirements.

3.11 Design Life The valves shall be capable of opening and closing 5000 times without major rework. The valves shall be capable of opening and closing 150 times without requiring maintenance of seats, seals etc.

3.12 Position Indication Remote position indication in at least one valve element position (on or off) shall be provided for each valve element. This indication shall be recorded during the open/close sequence.

3.13 Leakage Requirement All valves assemblies shall be leak tested to verify acceptable leakage at the conditions below. Downstream conditions for the test will be atmospheric, the flow media shall be dry nitrogen.

Full Scale	250 lbm/hr at 2250 psig and 700 F
	30 lbm/hr at 180 psig and ambient temperature
Half Scale	125 lbm/hr at 2250 psig and 700 F
	15 lbm/hr at 180 psig and ambient temperature

3.14 Rupture Disk Assembly

3.14.1 General The rupture disk assembly shall be designed to operate with or without the valve in place, with no modification required of either the valve assembly or the rupture disk assembly. This will require that the rupture disk assembly sealing plate be attached at two different locations in the expansion tube. The rupture disk assembly shall be supplied with all mounting hardware support saddles, gaskets, brackets and lifting eyes. Operating conditions for the half scale rupture disk assembly are 0 to 1860 psia internal pressure at 0 to 700 F internal temperature, and 0 to 2250 psig internal pressure at 0 to 700 F internal pressure for the full scale assembly. If it can be shown by analysis and testing that the full scale valve assembly can be opened sufficiently fast to produce a sharply defined shock wave (as determined by the U.S. Army Ballistics Research Laboratory), the rupture disk assembly will not be required for the full scale valves. However, design for the rupture disk assembly for the full scale valve shall be provided with the valve assembly full scale design. In all cases the rupture disk assembly design and fabrication will be required with the half scale valve. Rev. A

3.14.2 Rupture Disk Transition Piece This item will attach to the downstream side of the valve assembly and reduce concentrically from the diameter of the valve assembly to an 18 inch ID section. The included angle of this reducing section shall be 90^0, or 45^0 as measured from the center line to the reducing section wall. Straight walls on either side of this reducing section are required. Design shall be to the intent of ASME Section VIII, however, no code stamp is required. A 1 inch pipe stub with male NPT threads shall be provided near the upstream portion of the rupture disk transition piece for the purpose of admitting breathing air to the interior during periods of maintenance. A pipe cap shall be provided with this pipe stub. The rupture disk holder shall mount on the downstream end of the rupture disk transition piece. The rupture disk transition piece shall have a minimum length of 62.25 inches such that the rupture disk holder will project into the expansion tube without the valve in place. Lifting eyes shall be provided in locations such that the transition piece, with or without the rupture disk sealing plate attached, can be lifted into place in its normal horizontal orientation without the aid of additional rigging. Two bottom support saddles as shown in Figure 6 shall be provided on the half scale rupture disk transition piece. These support saddles shall be located as shown in Figure 3.

3.14.3 Rupture Disk Holder The rupture disk holder will mount on the downstream side of the rupture disk transition piece. This item shall hold and seal the rupture disks of 4.4 in place under full system pressure. Design of this item shall be to the intent of ASME Section VIII, however no code stamp is required. The rupture disk holder shall be mounted inside the expansion tube such that disk change out can be accomplished with a small hand operated monorail hoist. Lifting eyes shall be provided on the rupture disk holder to facilitate disk change out and maintenance. Designs which use through bolts from inside the expansion tube to the outside ~~the expansion~~ tube should be avoided to omit the need of change out personnel both inside and out side the tube. Gaskets and mounting hardware shall be provided with the rupture disk holder. The holder shall be designed to accept two rupture disks mounted in series. Each of these rupture disks shall hold half the system pressure, requiring that the volume between the to rupture disks be pressurized at half the total system pressure. Two 1/4 NPT female pressurization/cooling gas ports located 180^0 apart shall be provided in the void between the installed rupture disks. Pressurization equipment will not be a part of this specification. The spacing between the dual rupture disks shall Rev. A be less than 10 inches, and a minimum of 1 inch. The rupture disks shall discharge directly into the expansion tube, thus no downstream connections are necessary.

3.14.4 <u>Rupture Disks</u> Rupture disks will be used in some test operations to allow the rapid release of the high pressure gas in the driver tubes. To achieve the precise timing necessary to produce a sharply defined shock wave from multiple tubes, the downstream rupture disks will be burst by the use of linear cutting charges attached to the disks by the end user. In most tests, two rupture disks shall be used, each designed to take one half of the driver tube pressure. When the downstream disk is opened, the full system pressure is seen by the upstream disk, which then in turn ruptures, allowing the rapid escape of the driver tube gas. The purpose of the upstream rupture disk is to act as a heat shield for the cutting charges attached to the downstream disk. The upstream disk shall be sized to hold half the system pressure, but allow reliable disk rupture at full system differential pressure. At low driver tube pressures when ambient temperature driver tube gas is used, there is no need for the upstream heat shield disk, thus only the downstream disk with the cutting charges will be used. Fragmentation of the disks during actuation is undesirable. As a design goal, individual fragment particles should have a mass of less than 0.03 gram. Rupture disk tear off is unacceptable. Fragments from the cutting charge materials are understood to be beyond the control of the vendor. Cutting charges will not be required to be suppled with the rupture disks. However, disk development will require the use of cutting charges by the vendor during development to accurately model final disk rupture. Recommended charge configuration shall accompany each type of rupture disk provided. After rupture, the open disk area of each disk shall be at least 255 square inches, which is equivalent to an 18 inch ID orifice. Care shall be taken during the design so that this minimum open area is met should the displaced disk petals overlap

Rev. A

and/or contact the holder wall. A total of 35 rupture disk shall be provided, the type and amount are listed below.

Driver Tube Pressure, psig	Driver Tube Temperature, F	Upstream Disk Amount	Downstream Disk Amount
1860	700	5	5
1128	383	5	5
422	190	5	5
142	Ambient	0	5

This corresponds to five tests at each pressure.

3.14.5 Rupture Disk Assembly Seal Plate This item provides the seal between the rupture disk transition piece and the existing 96 inch ID expansion tube. An air tight seal is not required of the sealing plate. A 1/2 annular gap is permissible between the sealing plate and the mating components. The rupture disk sealing plate shall withstand an expansion tube internal pressure of 0 to 50 psi absolute. Design temperature range for the rupture disk sealing plate shall be -40 to 200 F. Attachment of the sealing plate to the expansion tube shall be by bolting to an attachment ring which is skip welded to the interior of the expansion tube. This sealing plate attachment ring will be ground out after test completion. The attachment ring and seal plate joint shall be designed to allow the seal plate to pass through the attachment ring. Two seal plate attachment rings will be required in the final system configuration, however only one attachment ring will be required to be supplied with the rupture disk assembly, and the other supplied with the valve assembly. Rev. A

3.15 Stress Analysis A stress analysis report which address the the ASME Section VIII analysis of all pressure boundary components shall be provided to EG&G Idaho as a part of the final design of all pressure retaining and load bearing components. REV A

3.16 Design Documentation The vendor shall supply the final design drawings, calculations, specifications for EG&G Idaho approval prior to the start of fabrication.

3.17 General Safety All valves and components shall be designed such that maintenance and inspection personnel are not subject to sharp edges and burrs. Also such operations shall not be required to be performed at high temperatures and pressures. Fragile items on the valve and components subject to accidental damage shall be adequately shielded or encased to minimize the risk to personnel and equipment.

3.18 Lifting and Support The valve assembly and the rupture disk transition piece shall be provided with supports and lifting eyes. The lifting eyes shall be placed such that the components can be lifted in their final orientation and placed in position. Lifting eyes shall be designed with a minimum safety factor of 5 based on the ultimate strength of the material used. Supports for the half scale valve and rupture disk transition piece shall be similar to Figure 6. Support of the full scale components shall be worked in conjunction with the facility design contractor and/or EG&G Idaho.

REV A

3.19 Project Phases and Required Schedule

Phase I	Concept Evaluation--Complete
Phase IIA	Half Scale Design--Valve assembly design complete, rupture disk assembly design partially complete.

Phase IIB	Half Scale Design Prototype Element Fabrication--Complete by May 1, 1989
Phase IIIA	Rupture Disk Assembly Fabrication--Ship by November 1, 1989
Phase IIIB	Half Scale Valve Assembly Fabrication--To Be Determined
PhaseIV	Full Scale Design--To Be Determined
Phase V	Full Scale Fabrication--To Be Determined

REV A

4.0 QUALITY ASSURANCE PROVISIONS

The manufacturer's quality assurance program shall meet the requirements of military specification MIL-Q-9858A, Quality Program Requirements. Also the manufacturer shall adhere to the requirements listed on the attached EG&G Idaho Form 1097 "Standard Quality Requirements for Suppliers.

5.0 PACKAGING

All material shipped to the customer shall be clearly marked as to its contents and packaged in such a way as to preclude shipping damage. Equipment should be assembled as much as practical and should have accompanying assembly, operation, and maintenance documentation. All equipment weighing over 40 lbs shall have lifting points and weight clearly indicated ~~and~~ shall be readily rigged for lifting.

6.0 NOTES

This section is not applicable to this specification.

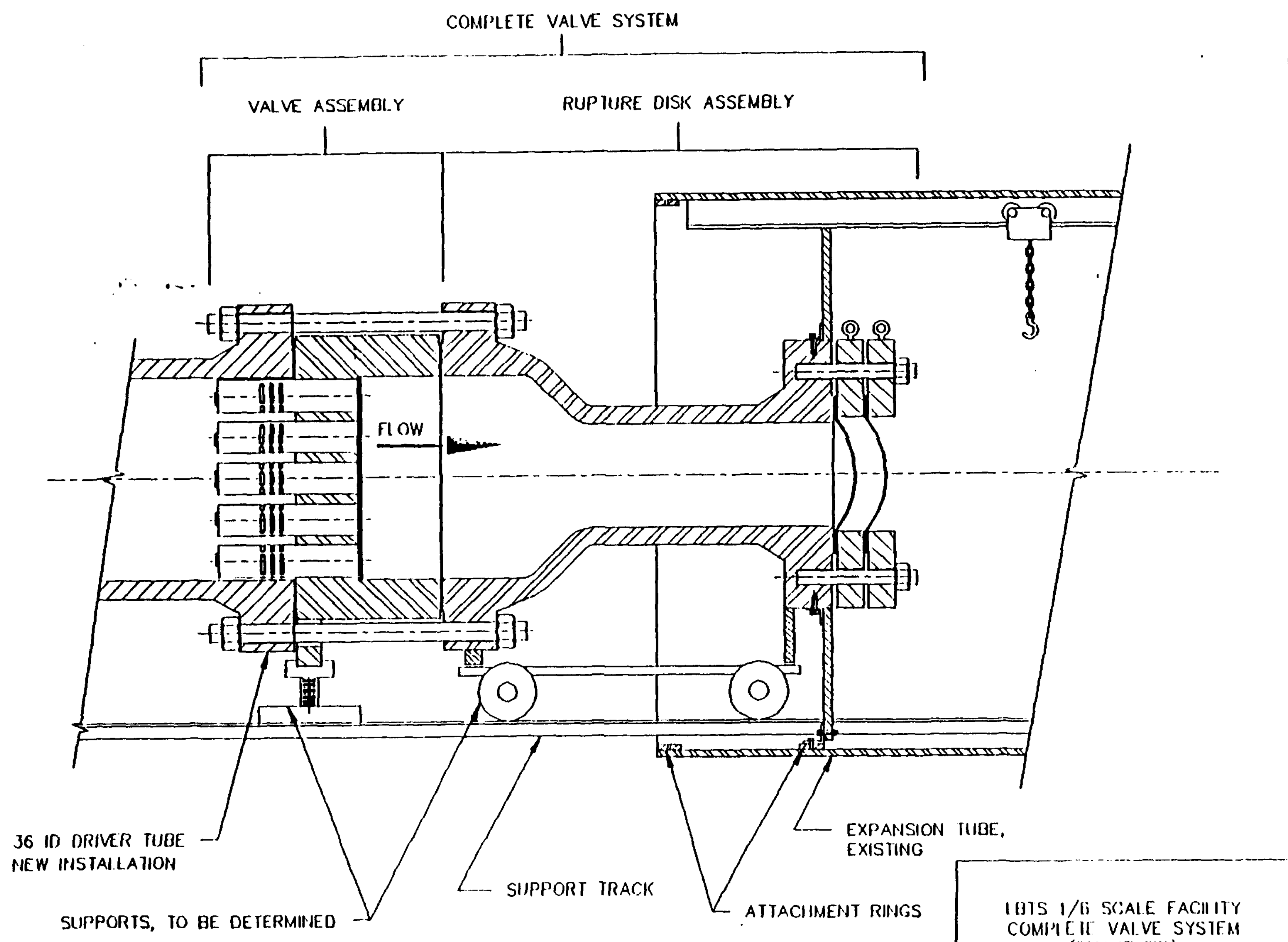

COMPLETE VALVE SYSTEM
VALVE ASSEMBLY
RUPTURE DISK ASSEMBLY
FLOW
36 ID DRIVER TUBE
NEW INSTALLATION
SUPPORT TRACK
SUPPORTS, TO BE DETERMINED
EXPANSION TUBE,
EXISTING
ATTACHMENT RINGS
LBTS 1/6 SCALE FACILITY
COMPLETE VALVE SYSTEM
(PHASE IIIB)

FIGURE 1

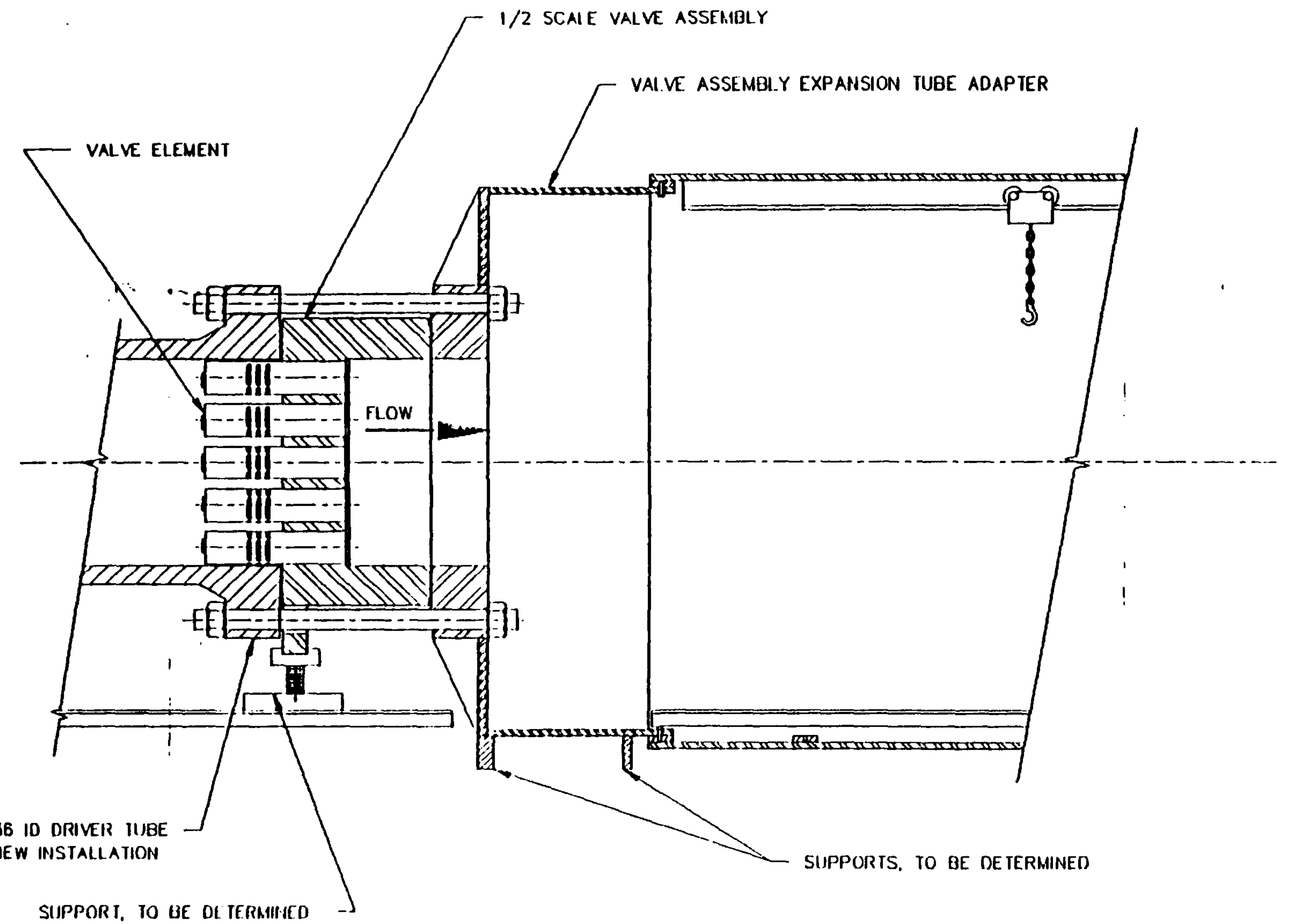


FIGURE 2

IBIS 1/6 SCALE FACILITY
VALVE ASSEMBLY ONLY
WITH EXPANSION TUBE ADAPTER
(PHASE IIIB, OPTIONAL)

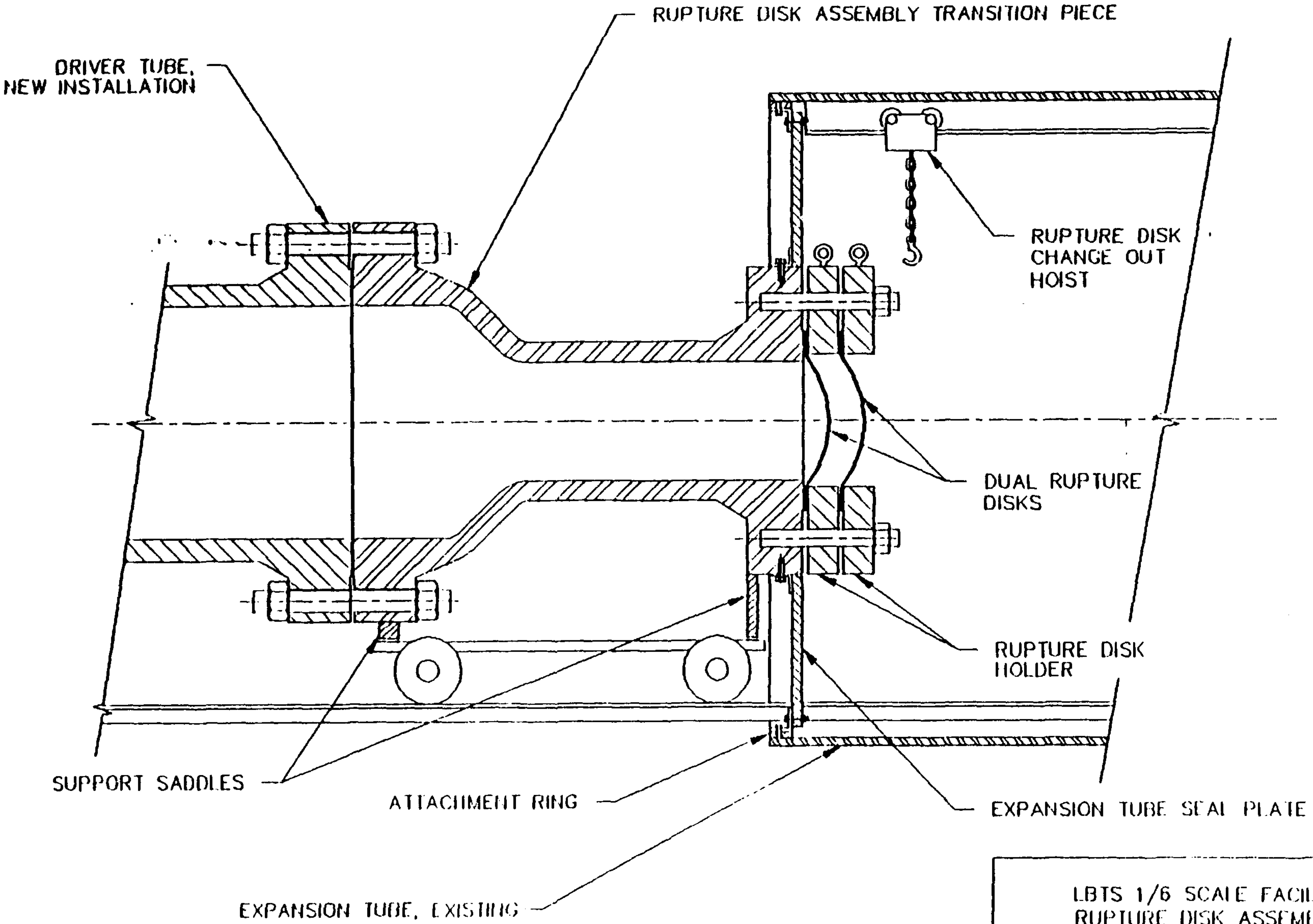
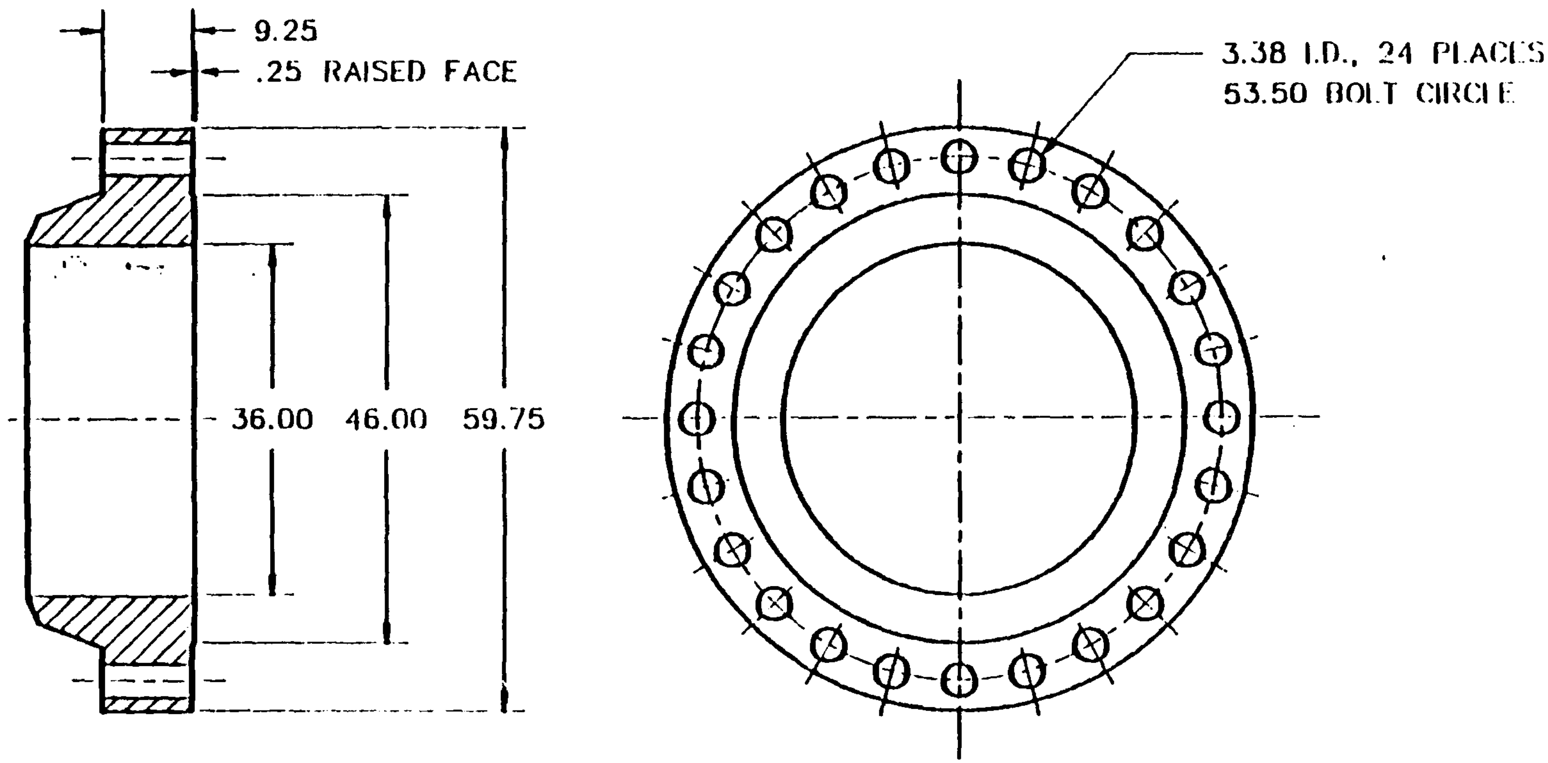


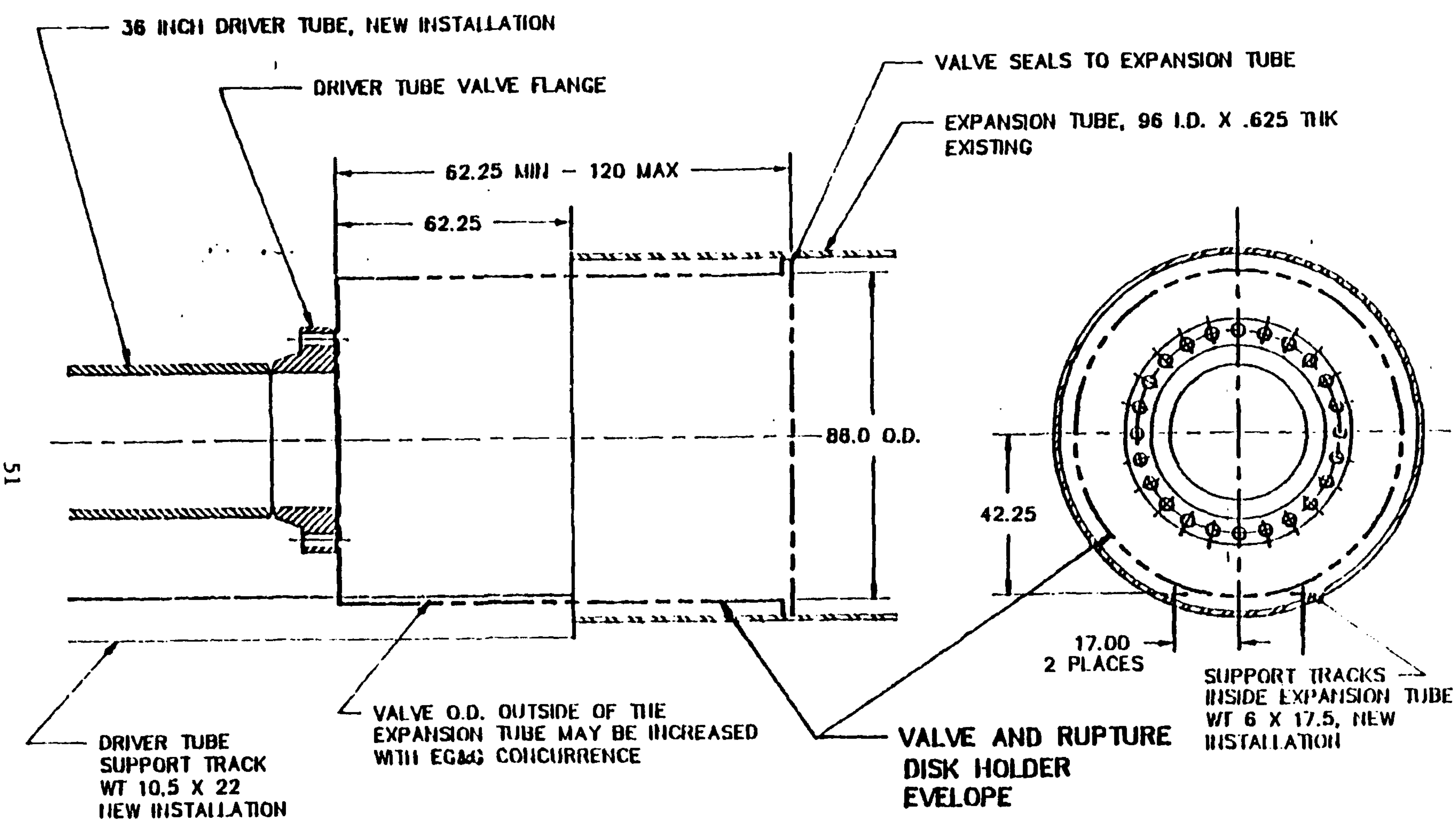
FIGURE 3

LBTS 1/6 SCALE FACILITY
RUPTURE DISK ASSEMBLY
VALVE NOT USED
(PHASE IIIA)



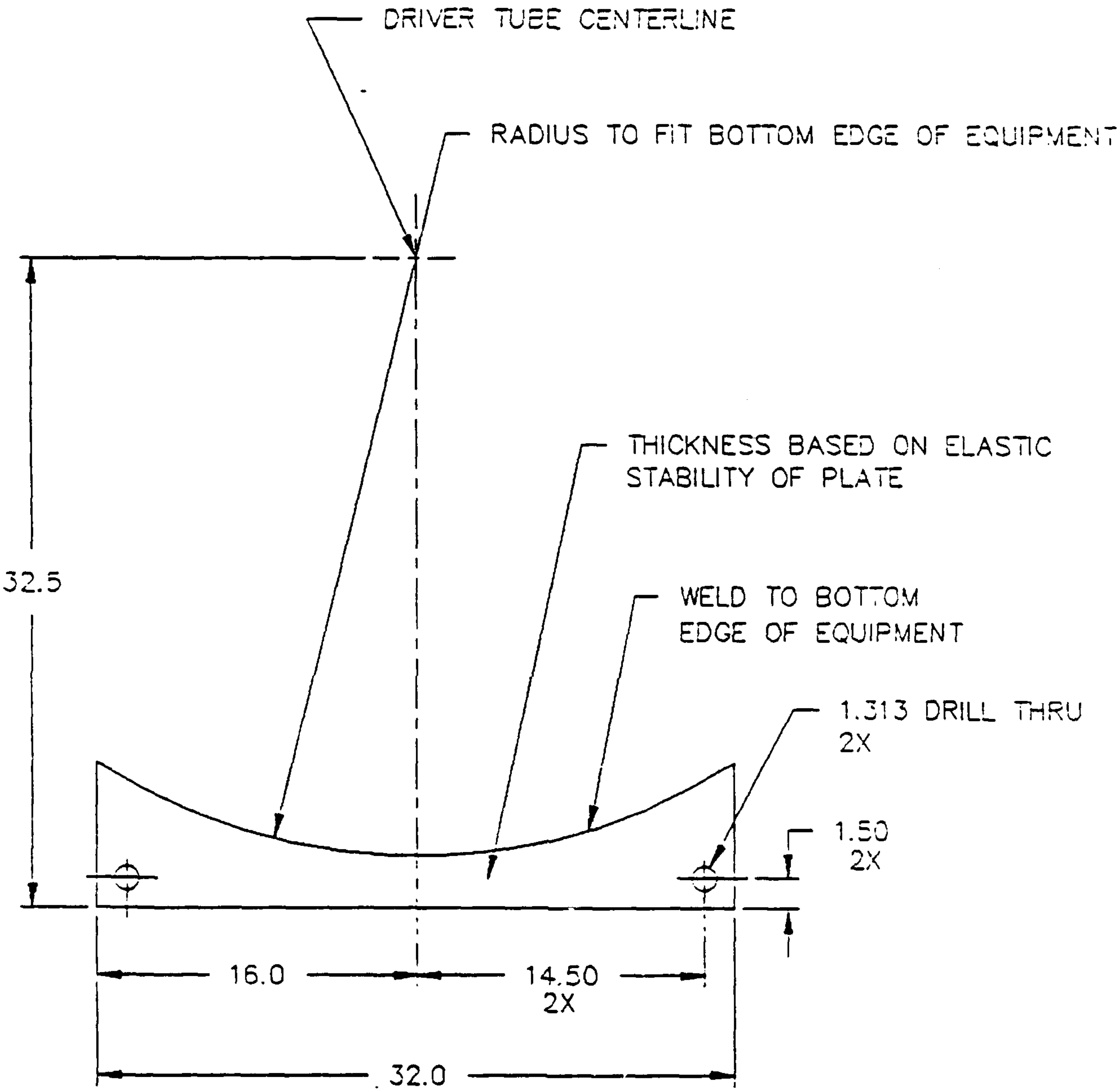
1/2 SCALE
36 INCH DRIVER TUBE
VALVE FLANGE

FIGURE 4



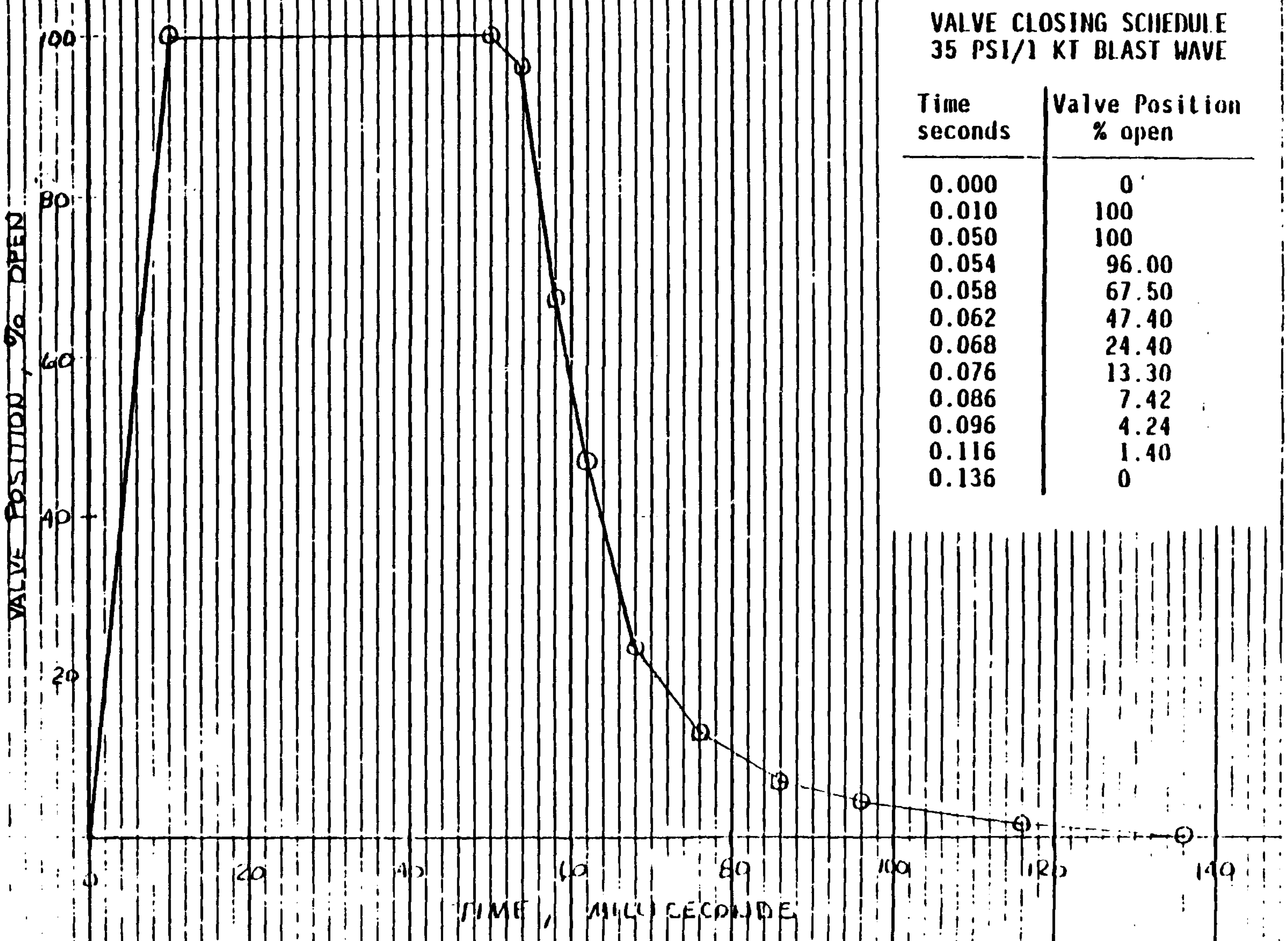
VALVE ASSEMBLY ENVELOPE FOR HALF SCALE FACILITY

FIGURE 5



TYPICAL SUPPORT
LBTS 1\2 SCALE VALVE
AND TRANSITION PIECE

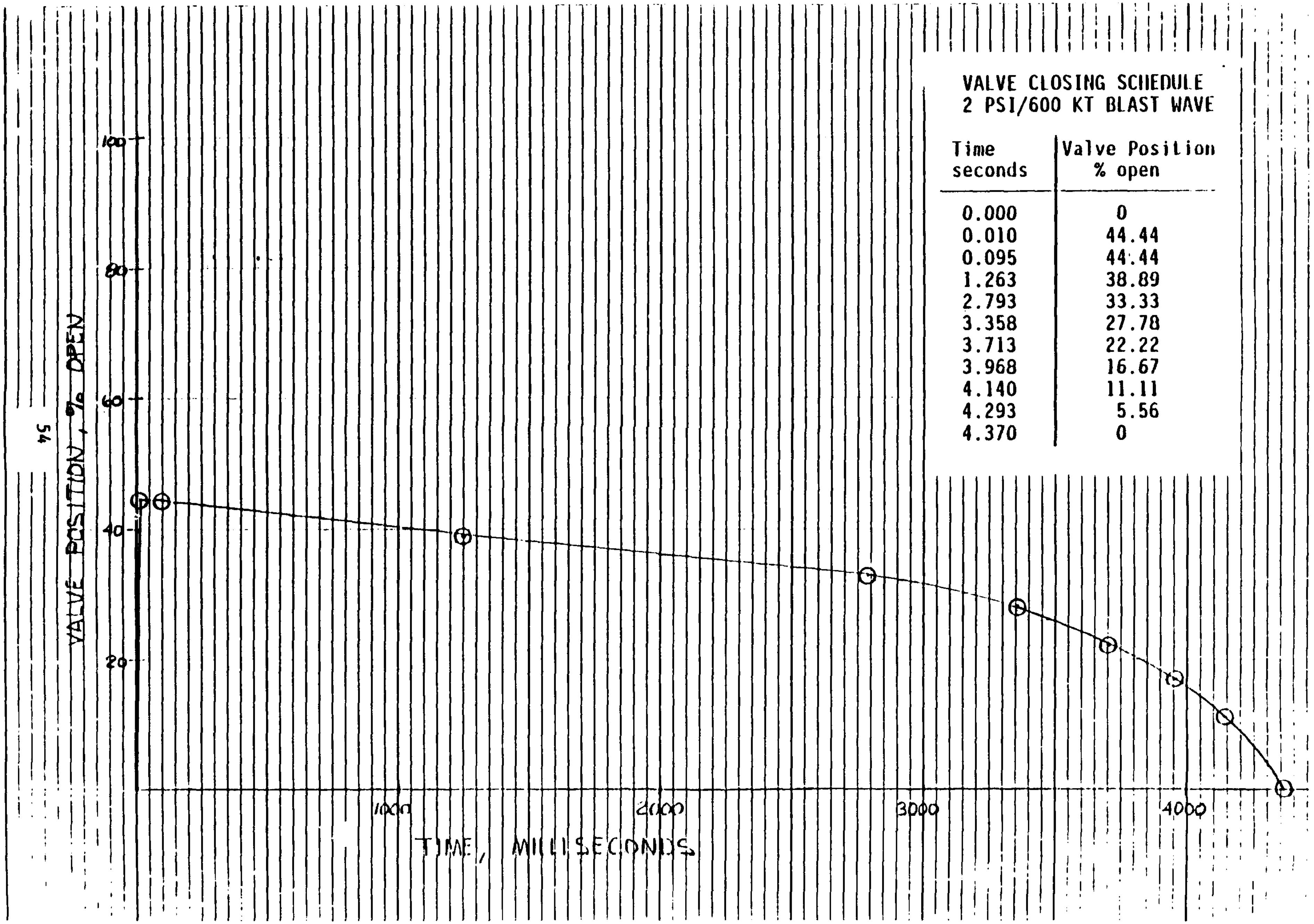
FIGURE 6



VALVE CLOSING SCHEDULE
35 PSI/1 KT BLAST WAVE

Time seconds	Valve Position % open
0.000	0
0.010	100
0.050	100
0.054	96.00
0.058	67.50
0.062	47.40
0.068	24.40
0.076	13.30
0.086	7.42
0.096	4.24
0.116	1.40
0.136	0

46 0700

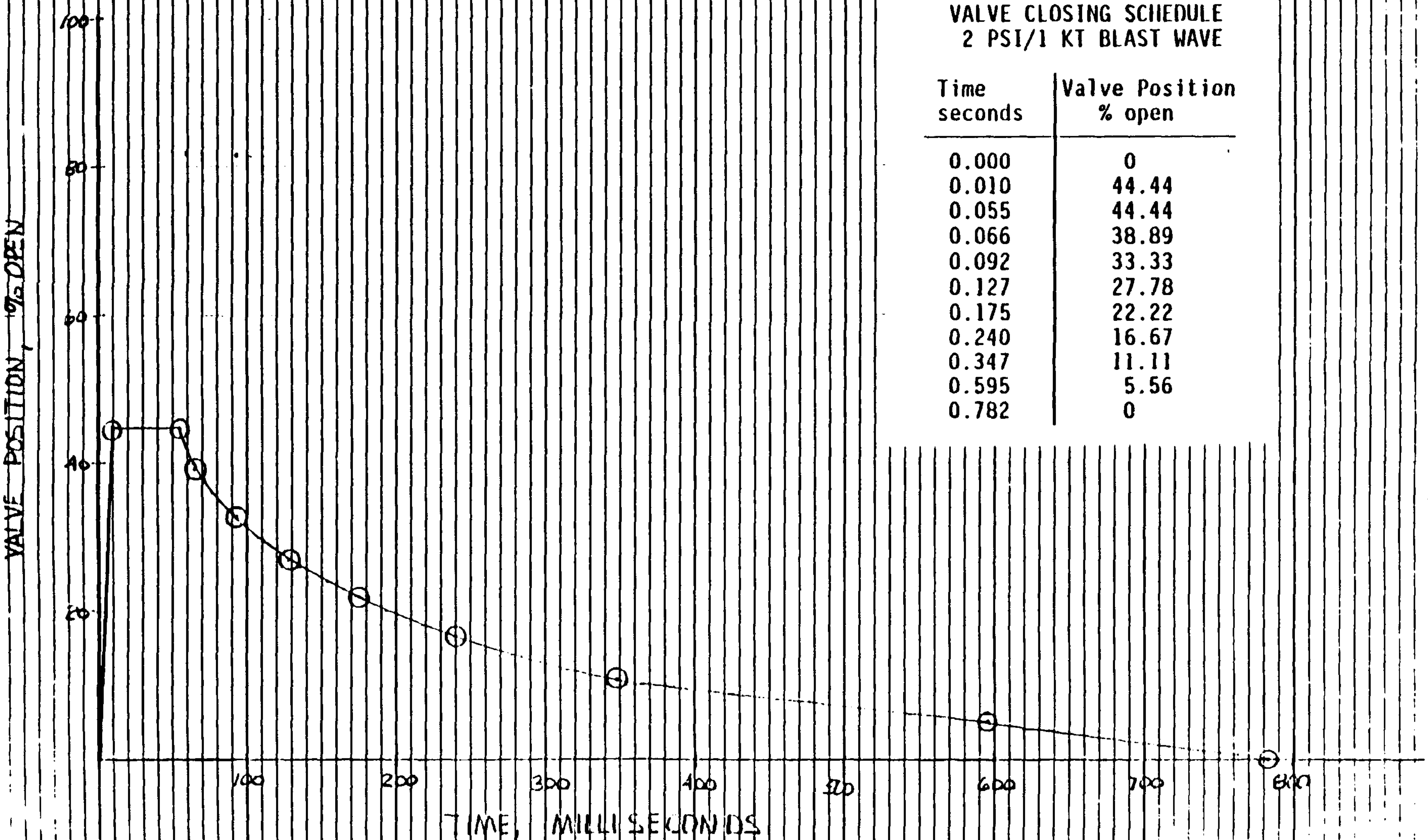


VALVE CLOSING SCHEDULE
2 PSI/600 KT BLAST WAVE

Time seconds	Valve Position % open
0.000	0
0.010	44.44
0.095	44.44
1.263	38.89
2.793	33.33
3.358	27.78
3.713	22.22
3.968	16.67
4.140	11.11
4.293	5.56
4.370	0

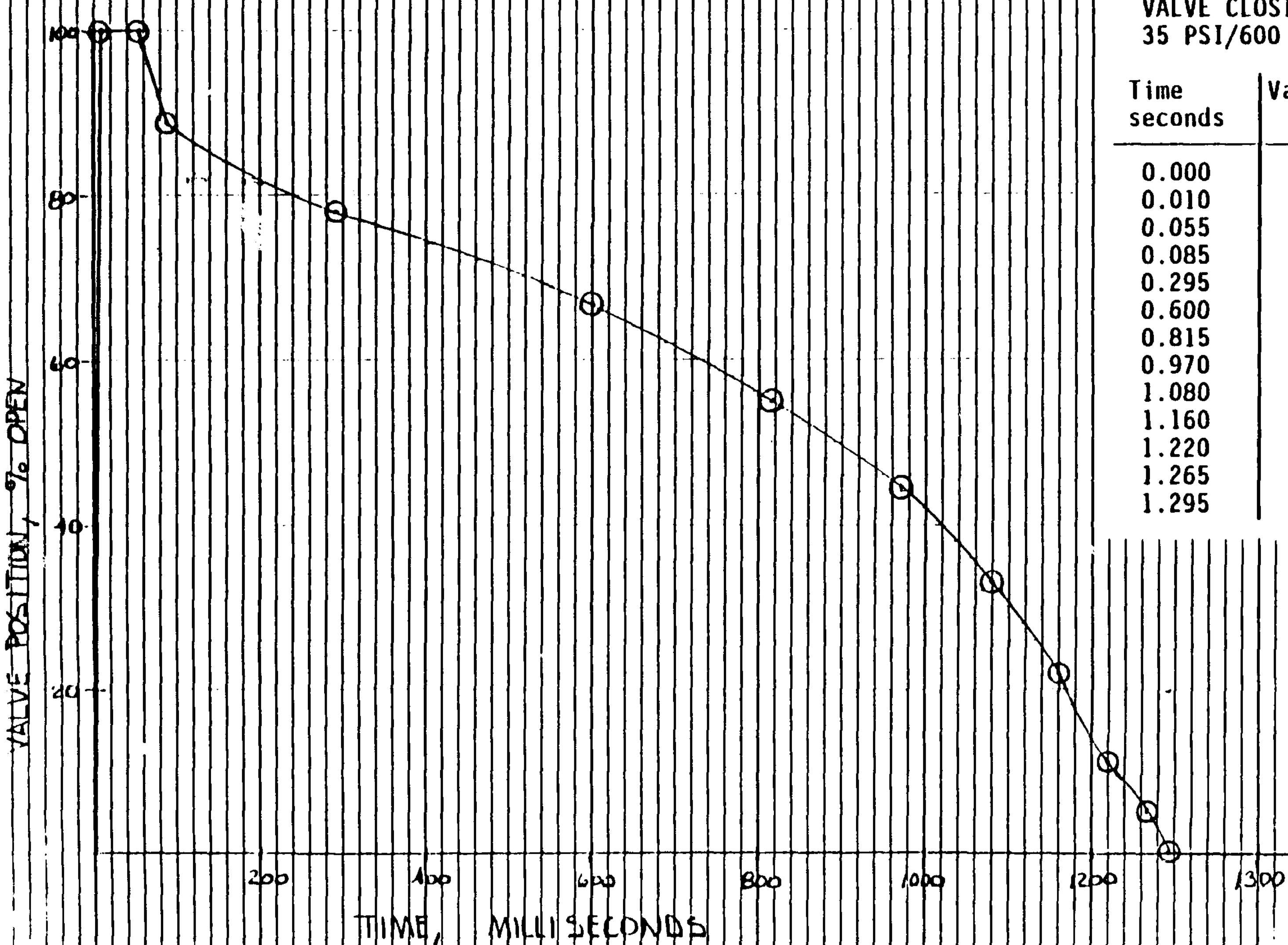
FIGURE 7P

JED PITT 8/8/88



VALVE CLOSING SCHEDULE
2 PSI/1 KT BLAST WAVE

Time seconds	Valve Position % open
0.000	0
0.010	44.44
0.055	44.44
0.066	38.89
0.092	33.33
0.127	27.78
0.175	22.22
0.240	16.67
0.347	11.11
0.595	5.56
0.782	0



VALVE CLOSING SCHEDULE
35 PSI/600 KT BLAST WAVE

Time seconds	Valve Position % open
0.000	0
0.010	100
0.055	100
0.085	88.89
0.295	77.78
0.600	66.67
0.815	55.56
0.970	44.44
1.080	33.33
1.160	22.22
1.220	11.11
1.265	5.56
1.295	0

FIGURE 7D

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